PANORAMIC RADIOGRAPH AND CONE BEAM COMPUTED TOMOGRAPHY- EVALUATION OF MANDIBULAR IMPACTED THIRD MOLAR AND MANDIBULAR CANAL

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CERTIFICATE

This is to certify that **Dr.Khushboo Singh**, Post graduate student (2010 – 2013) in the Department of Oral Medicine and Radiology branch IX, Tamil Nadu Government Dental College and Hospital, Chennai – 600 003 has done this dissertation titled **“Panoramic radiograph and Cone beam computed tomography - Evaluation of Mandibular impacted third molar and Mandibular canal”** under my direct guidance and supervision for partial fulfillment of the M.D.S degree examination in April 2013 as per the regulations laid down by Tamil Nadu Dr.M.G.R. Medical University, Chennai - 600 032 for **M.D.S., Oral Medicine and Radiology (Branch – IX)** degree examination.

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CONTENTS

ABBREVIATIONS

B-L	Bucco-Lingual
CT	Computed Tomography
CBCT	Cone Beam Computed Tomography
CBVI	Cone Beam Volumetric Imaging
CMOS	Complementary Metal Oxide Semiconductor
DSA	Digitally Subtracted Angiography
DR	Darkening of Roots
DMC	Deviation of Mandibular Canal
et al	And Others
FPD	Flat Panel Detector
FOV	Field of View
H × W	Height by Width
IAN	Inferior Alveolar Nerve
IAC	Inferior Alveolar Canal
IWL	Interruption of White line of Mandibular Canal
KV	Kilovoltage
LTM	Lower Third Molar
mSv	Millisieverts
MA	Milliampere
MTM	Mandibular Third Molar

MNBR	Multiprojection Narrow-beam Radiography
µSv	Microsieverts
NRCP	National Council on Radiation Protection and Measurements
NMC	Narrowing of Mandibular Canal
OPG	Orthopantamogram
PAN	Panoramic Radiograph
ROI	Region of Interest
S-I	Supero-Inferior
SMC	Superimposition of Roots on Mandibular Canal
SPSS	Statistical Package for Social Sciences
3-D	3- Dimensional

ABSTRACT

Background: Management of mandibular third molar teeth requires accurate and precise information regarding exact location and its relationship with the inferior alveolar nerve (IAN) where these two structures are intimately related to prevent the injury of the nerve. For pre-operative screening of the cases, intraoral and panoramic radiograph is sufficient to determine the position of the third molar in relation to inferior alveolar nerve. But with advent of cone beam computed tomography (CBCT), it has become easy to localize the exact position of the tooth and IAN in all the three planes where both are closely related.

Aim: The aim of the study was to evaluate the diagnostic utility of CBCT in preoperative assessment of impacted mandibular third molars where root tip is in direct proximity of the IAN as evaluated in panoramic radiograph.

Materials and Methods: Study sample was composed of 20 patients (40 teeth). High risk signs of IAN injury such as darkening of roots, interruption of white line of mandibular canal, superimposition of roots on mandibular canal, narrowing of mandibular canal, and deviation of mandibular canal were assessed in panoramic radiograph and subsequently CBCT images were evaluated for exact location of mandibular canal in relation to root tip, cortical lining of mandibular canal, and cortical plate perforation.

Results: In most of the cases mandibular canal in relation to root tip was at the level of roots and inferiorly positioned. There was statistical significant association between darkening of roots and cortical plate perforation, interruption of white line and absence of corticalisation of mandibular canal and superimposition of roots on mandibular canal and presence of corticalisation of mandibular canal.

Conclusion: In the present study, exact localization of mandibular canal was done in relation to the mandibular third molar in all three planes with the help of CBCT in the cases showing the high risk signs of IAN injury. CBCT proved to be a promising diagnostic tool for preoperative assessment of mandibular third molar tooth and IAN in complicated cases.

Key words: Mandibular canal, panoramic radiograph, Cone beam computed tomography

INTRODUCTION

Impaction is a pathological condition which is defined as "lack of eruption of a tooth in the oral cavity within the time and physiological limits of normal eruption process".[1] A fully developed tooth which remains in the jaw bone or under the mucosa even after its normal eruption time is known as an impacted tooth. Most commonly encountered impacted teeth are third molars, followed by maxillary canine and mandibular 2nd premolar.[2] Removal of the third molar is the routine surgical procedure in dentistry. Indications for removal of an impacted mandibular third molar are orthodontic reasons[3], pericoronitis[4,5], odontogenic cysts or tumors[6,7,8], untreatable caries with accompanying pain sensation or apical infection[7], external root resorption of second molar.[9] Management of impacted teeth requires accurate and precise diagnosis regarding location of an impacted tooth and its relationship with the surrounding anatomical structures. It is important to determine and evaluate the exact position of an impacted tooth, inclination of long axis of an impacted tooth and its relationship to the neighboring structures such as adjacent teeth, vital neurovascular structures. Neurological complications may occur because of inappropriate diagnosis of the neighbouring anatomic structures or the surgical approach in the cases, having close or intimate relationship between roots of mandibular third molar and mandibular canal and or mandibular lingual cortex. The removal of an impacted mandibular third molar can injure the inferior alveolar nerve (IAN) and cause dysesthesia.[10,11] The root tip position of an impacted mandibular third molar is the very important and decisive factor for the nerve injury incidence. If the position of the root tip is below the mandibular canal, the risk is approximately 3 times higher than the average.[12,13] The incidence of inferior alveolar nerve damage is increased upto 30% in cases where the root of mandibular third molar is in direct contact with the inferior alveolar nerve.[14,15,16,17] The radiographic and imaging examination is certainly an indispensible tool for precise diagnosis and optimal management without any further complication because it provides valuable information about tooth position, number and morphology of roots, and relationship of tooth to adjacent anatomical structures. Always the first choice of imaging modality should be the plain or conventional radiography when an impacted tooth is suspected after clinical examination. For preoperative diagnosis of routine cases, intraoral and panoramic radiographs are sufficient to determine the position of the third molar in relation to inferior alveolar canal. But additional information from other imaging modalities is needed in the second plane if the tip of root is on the level or inferior to the mandibular canal to identify the position of root tip in relation to mandibular canal.[18] Moreover conventional radiographs have their inbuilt drawbacks like superimposition, distortion of images, because of the projection of 3dimensional structures in 2 dimension hence the advanced imaging is necessary for the assessment of impacted molars. Some studies used panoramic radiographs as a guideline for deciding whether an axial CT (Computed tomography) was needed in addition to preoperative panoramic radiograph for patients to undergo third molar extraction.[19]

CT has been used for past several years because it can provide additional and reliable information than conventional radiographs. CT provides good tissue contrast, eliminates blurring of image and overlapping of adjacent anatomical structures. CT requires thin slices and a resulting high radiation dose to get precise information of the very fine anatomic structures of the root tip and the surrounding structures.[20,21,22,23]

Despite its advantages, until now, the use of CT for the assessment of impacted teeth has been restricted because of issues related to cost, risk versus benefit, and access.[18]

CBCT (cone beam computed tomography) is a recent technology initially developed for angiography in 1982 and subsequently applied to maxillofacial imaging.[24] It uses a divergent or "cone"-shaped beam of ionizing radiation and a two dimensional detector fixed on a rotating gantry to obtain multiple sequential projection images in one complete scan of the area of interest.[24] It is only since late 1990s that it has become possible to produce clinical systems that are both inexpensive as well as small enough to be used in the dental office.[24]

Currently, many attempts through various studies have been made to investigate the role of CBCT in the imaging of impacted teeth. CBCT imaging has the benefit of lesser radiation exposure to the patient as compared to CT.

CBCT provides high definition three dimensional images of all oral and maxillofacial structures at reduced cost and lesser radiation dose to the patient. It has also overcome all the limitations of conventional imaging such as distortion of image, magnification of image, less clarity, overlapping of anatomical structures, lack of accuracy in measurements and not allowing for 3dimensional modeling. With the advent of CBCT, it has become very convenient, simple and easy to determine the exact location of impacted tooth in the jaw and its relation to the adjacent teeth as well as anatomic structures. Many different radiographic projections were required for the localization of an impacted tooth traditionally. Although these projections were able to identify whether the tooth was buccal or lingual, it was still difficult to assess the proximity of impacted tooth to the roots of adjacent teeth and underlying anatomical structures.

With CBCT, the diagnosis has become a simple illustrative task, viewing the entire dentition as well as the impacted teeth. Further additional information such as three dimensional orientation of an impacted tooth, and direction of path of eruption is best revealed with CBCT.

The present study was aimed to evaluate the diagnostic utility of CBCT in assessment of relationship of mandibular canal with the impacted mandibular third molars where these two structures are closely related to each other bearing high risk chances of IAN injury.

AIM

The aim of the study is to evaluate the diagnostic utility of cone beam computed tomography (CBCT) in preoperative assessment of impacted mandibular third molars where the root tip is in direct proximity of the inferior alveolar nerve.

OBJECTIVES

- The primary objective of the study is to compare the cone beam computed tomography (CBCT) and panoramic radiograph for localization of the mandibular canal in respective to impacted mandibular third molars.
- The high risk injury signs to inferior alveolar nerve in panoramic radiographs such as darkening of roots, interruption of white line of mandibular canal, narrowing of mandibular canal, superimposition of roots on mandibular canal, deviation of mandibular canal, and combination of these findings [13,17,25,26] were evaluated and correlated with following CBCT findings:
  i. Bucco-lingual position of mandibular canal
  ii. Supero-inferior position of mandibular canal
  iii. Presence or absence of corticalisation of mandibular canal
  iv. Cortical plate perforation

REVIEW OF LITERATURE

Definition:

"Impacted teeth can be defined as those teeth that are prevented from eruption due to a physical barrier within the path of eruption" [32] (Farman, 2004).

"Peterson defined the term impaction as one that fails to erupt into the dental arch within the expected time" [33] (Peterson, 1998).

"Another definition states that an impacted tooth is one which, for various reasons does not erupt into the correct position in the dental arch at the appropriate time" [34,35] (Archer, 1966, Edelman and Hasharon, 1979).

"Mead has defined an impacted tooth as a tooth that is prevented from erupting into position because of malposition, lack of space, or other impediments" [36] (Mead, 1954).

Four important etiologic factors which are reported in literature to explain impaction:[37]

1) Obstruction in the path of eruption.

2) Ectopic position of the tooth.

3) Lack of adequate guidance along the roots of the adjacent tooth.

4) General systemic diseases.

Importance of Localization of Impacted Teeth:[38]

The following reasons make it important to localize impacted teeth:

1. The basic principle is to not extract a well-placed tooth in proper occlusion in order to make a space for a poorly positioned tooth. If a well-placed tooth is conserved, treatment

time may be shortened considerably, and the result will be more definite. At the same time, reverse also holds true. If a poorly placed tooth is kept intact and a well-aligned tooth is extracted, then treatment time will be prolonged and the result will be less certain.

2. An error in localization can lead to removal attempted in the wrong area.

3. The clinician must be able to assess the difficulty involved in exposing a displaced tooth. Exposure of a malpositioned tooth may be more hazardous to the adjacent teeth than extracting it.

The clinician may require following details about impacted teeth before intervention-

1. The precise and exact position of the crown and root apex of an impacted tooth.

2. The proximity of impacted tooth to the roots of adjacent teeth and anatomic structures.

3. The presence of any pathology and their spatial relationship with impacted tooth.

4. The orientation of anatomy of impacted tooth in 3-dimension.

Methods of Localization of impacted tooth:

There are three methods of localization:

- Inspection
- Palpation
- Radiographic and imaging modalities.

Inspection

Impacted tooth may produce bulging of the overlying mucosa on the buccal or palatal aspect on inspection.

Impacted tooth may also produce drifting of adjacent teeth as an inspectory finding.

Palpation

It is the next step in localization of impacted teeth. On palpation, an impacted tooth can present as a bulge or swelling or prominence. Occasionally on palpation the bony prominence may obscure an impacted tooth, and the fact that the tooth is impacted can be missed. On palpation, if a tooth is palpable in an abnormal position or cannot be palpated, radiographs are necessary for its localization.

Radiography-

Dental radiology has played an exciting, vital and critical diagnostic role in dentistry, and has brought revolution in medical field with the invention of newer rapidly expanding wide array of imaging modalities.

Intraoral radiography was first used within weeks of the discovery of X rays by Roentgen in 1895. Extraoral imaging, including cephalometric radiography, followed soon thereafter. Panoramic radiography has provided broad coverage of the teeth and surrounding structures since the mid-twentieth century. Each of these modalities has adapted to the digital revolution. Recent decades have seen the development of CT, MRI, nuclear medicine, and ultrasonography, imaging modalities that have revolutionized dental and medical diagnosis.

Localization of impacted teeth can be done by conventional radiographs[39] like orthopantomography (OPG), lateral cephalometric radiograph, open mouth PA view, parallax method, occlusal radiography and advanced radiographic techniques like computerized tomography. Recently Cone beam computed tomography has been introduced for localization of impacted teeth.

Panoramic radiography- It is the basic and routine fundamental radiograph which is simple and easy to perform and provides useful information regarding mandibular symmetry, the number of teeth present, parallelism of the roots, sequence of dental eruption, dental age, resorption of teeth, presence of pathology, variation inrelation to normal teeth as well as provides information of other structures also such as paranasal sinuses and temporomandibular joint articulation.[40] Panoramic radiograph is also used to estimate the mesiodistal and vertical dimensions of impacted teeth.[39] However, localization of impacted tooth in a bucco-palatal plane is difficult, since it is a 2 dimensional radiograph. It has some advantages compared with normal computed tomography (CT), including lesser exposure of radiation to the patient, ease of use, less patient chair side time, better patient cooperation, lower cost, and more frequent availability in most of the dental offices whereas drawbacks are magnification, distortion, and overlapping of the anatomical structures.

Computerized tomography (CT) - In some past recent years, CT has become the imaging modality of choice as they provide more realistic information than conventional radiographic imaging techniques. Computerized tomography was developed by **Sir Godfrey Hounsfield in 1967** and since the first prototype, there has been a gradual evolution to five generations of such systems. The method of classification for each system is based on the organization of the individual parts of the device and the physical motion of the beam in capturing the data. CT provides excellent tissue contrast and eliminates blurring of image and overlapping of adjacent anatomical structures.

Nonetheless, there are several limitations also with this modality. It requires the large amount of considerable physical space and is much more expensive than other conventional radiographic methods. The images which are captured on the detector screens are made up of multiple axial slices, which are ‘stacked’ to obtain a final complete image making it time consuming. CT scan provides accurate position, orientation, and inclination of an impacted tooth, its relationship with adjacent neighbouring anatomical structures in all the three dimensions. With CT, it has become possible to localize impacted teeth accurately and precisely, relationship of impacted teeth with adjacent vital anatomic structures, presence of root resorption in the adjacent teeth and also detects the associated pathology if present. However due to high cost and especially high radiation doses[39], routine use of CT for diagnosis of an impacted tooth is not justified. Currently the only indication of CT scan is where the patients show displacement of long axis of tooth due to abnormal orientation of the root apex, the presence of resorption of root or cases where exact localization of impacted teeth and its prognosis cannot be elicited by routine radiographs. It has been shown that it is superior to plain radiographs in accurately determining the crown shape, crown root relationship and orientation, and relationship to surrounding anatomic structures.[41]

Craniofacial CBCTs were designed to counteract some of the limitations of the conventional CT scanning devices.[42] The object to be evaluated is captured as the radiation source falls onto a two-dimensional detector. This simple difference allows a single rotation of the radiation source to capture an entire region of interest, as compared to conventional CT devices where multiple slices are stacked to obtain a complete image.[43] The cone beam also produces a more focused beam of x-ray and significantly less scatter radiation compared to the conventional fan-shaped CT devices, and this considerably increases the X-ray utilization and reduces the ability of X-ray tube required for volumetric scanning.[44,45] It has been reported that the total radiation dose is approximately 20% of conventional CTs and equivalent to a full mouth periapical radiographic exposure.[46] These component innovations are significant and allow the CBCT to be less expensive and smaller. Furthermore, the exposure chamber (i.e. head), is custom built and reduces the amount of radiation. The images are comparable to the conventional CTs and also may be displayed as a full head view, as a skull view or regional components depending upon the field of view.

Cone beam computed tomography (CBCT)-

It is a recent innovation in field of technology that has achieved the rapid acceptance in general particularly in dentistry despite its current relatively high price when compared with alternative imaging methodologies.

Robb RA reported the use of first CBCT scanner for angiography among at Mayo Clinic in 1982.[47] Later, several other systems were developed specifically for angiography. **Fahrig et al**. developed a CBCT system based on an image intensifier and C-arm for use in angiography.[48] **Saint-Felix et al** developed a CTA CBCT system based on the gantry of a conventional CT scanner which reconstructs vasculature from a set of digitally subtracted angiography (DSA) images.[49]

CBCT systems are also used for radiation therapy planning, in mammography, and interoperatively for otorhinolaryngological surgery. **Jaffray and Siewerdsen** developed a CBCT system for radiotherapy guidance based on an amorphous silicon (a-Si:H) flat-panel detector.[50]

In late 1990s only that it has become possible to create clinical systems that are both inexpensive and small enough to be used in the dental office. The **first commercial CBCT system** for oral and maxillofacial imaging was the NewTom (Quantitative Radiology, Verona, Italy), which was first approved by the Food and Drug Administration (FDA) in **April 2001**, and is currently in its fourth generation as the NewTom VG. Since that time numerous additional systems have been approved or are in development.[43]

Presently, the available CBCT equipments differ in size, possible settings, area of image capture (field of view), and clinical usage.

CBCT has application in several diagnostic areas, such as implant treatment, oral surgery, endodontic treatment, and tempomandibular joint imaging. The great advantage of this technology is that offers 3-dimensional (3D) imaging of dental structures and provides clear images of highly contrasted structures, such as bone. In comparison to the conventional computed tomography, CBCT technology in clinical practice has significant advantages such as minimization of the dose of radiation to the patient, accuracy of image, rapid scanning time, lesser image artifacts, chair-side image display, high spatial resolution and real-time analysis.[40, 51, 52]

It uses a divergent or “cone”-shaped[52] source of ionizing radiation and a two dimensional area detector fixed on a rotating gantry to acquire multiple sequential projection images in one complete scan around the area of interest. Four technological factors have contributed to make this possible: 1) the development of compact high quality flat panel detector arrays, 2) reduction in the cost of computers capable of image reconstruction, 3) development of inexpensive X-ray tubes capable of continuous exposure and, 4) limited volume scanning (e.g., head and neck), eliminating the requirement of sub second gantry rotation speeds.[24]

This technology has been given several names including-

Dental Volumetric Tomography

Digital Volumetric Tomography

Cone Beam Volumetric Tomography

Cone Beam Computed Tomography

Dental Computed Tomography

Cone Beam Imaging

Principles of cone beam computed tomography-

All CT scanners consist of an x-ray source and detector mounted on a rotating gantry. During rotation of the gantry, the receptor detects x rays attenuated by the patient. These recordings constitute "raw data" that is reconstructed by a computer algorithm to generate cross sectional images whose component picture element (pixel) values correspond to linear attenuation coefficients. CT can be divided into 2 categories on the basis of acquisition x ray beam geometry, namely fan beam and cone beam.[24] Cone beam scanners use a 2 dimensional digital array providing an area detector unlike linear detector as CT does. This is combined with a three dimensional (3D) x-ray beam with circular collimation so that the resultant beam is in the shape of a cone, hence the name "cone beam." Because the exposure incorporates the entire region of interest (ROI), only one rotational scan of the gantry is necessary to acquire enough data for reconstruction. Cone beam geometry has inherent quickness in volumetric data acquisition and therefore the potential for significant cost savings as compared with CT, CBCT produces an entire volumetric dataset from which the voxels are extracted. Voxel dimensions are dependent on the pixel size on the area detector. Therefore CBCT units in general provide voxel resolutions that are isotropic- equal in all three dimensions.[24]

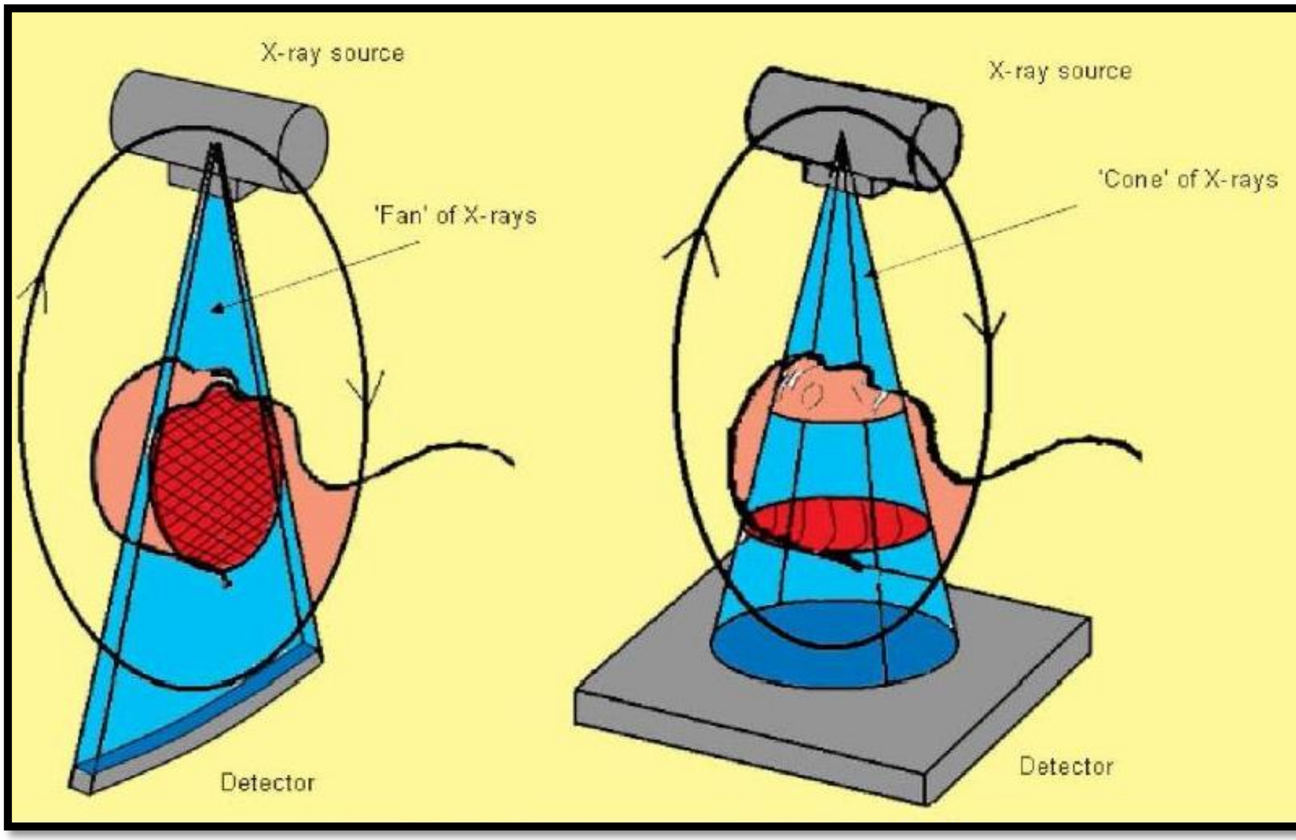


Fig 1: A. Fan shaped x-ray beam with linear detector in Conventional CT

B. Cone shaped beam of x-rays with flat panel detector in CBCT

Field of View-

Scanners using flat panel detectors (FPD) describe the dimensions of their cylindrical field of view's (FOV) as height by width (HxW). Width also can be referred to as diameter. Field of view refers to the area of the anatomy that is captured by the scan. Scanners are grouped into three categories based on their field of view.

1. Large field of view-

A scanner with large field of view will show the roof of the orbits and nasion down to the hyoid bone. Scanners with large FOV, usually a FOV height equal to or greater than 16 cm, are useful for cephalometrics and traditional orthodontic surveys.

Eg- Next Generation (Platinum) i-CAT developed by Imaging Sciences International has a FOV of 17x23 cm.

Kodak 9500 developed by Carestream has a FOV of 18x21cm.

New Tom 3G developed by Imaging Sciences has a FOV of 20x20x20 cm

2. Medium field of view-

Medium FOV scanners will capture the middle of the orbits down to menton vertically, and condyle to condyle horizontally. Scanners with a medium FOV are useful for panoramic radiograph and implant surveys, but not for cephalometric analysis.

Eg- New Tom 9000 by Aperio services has a FOV of 15x15x15cm

I-CAT services by Imaging Sciences International have a FOV of 8x14 cm.

3. Small field of view-

Scanners with a small FOV capture a user-defined region, usually symmetrical in shape. Small FOV scanners are used for implant surveys, TMJ surveys, and the localization of impacted teeth.

Eg- Kodak 9000 3D and Kodak 9000 3DC developed by Carestream has a FOV of 4x5cm

ProMax 3D manufactured by Planmeca has a FOV of 8x8cm.

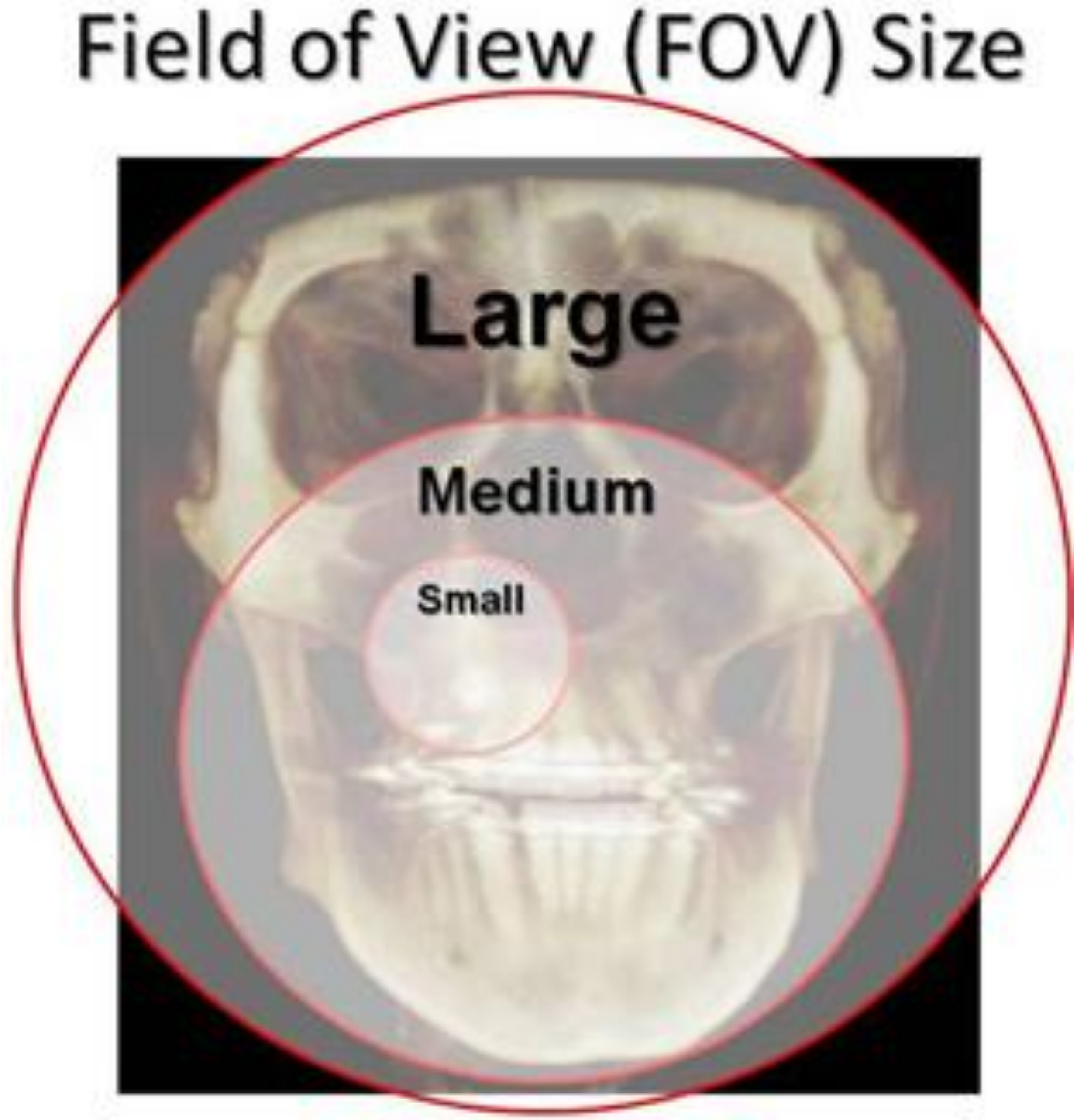


Fig 2: CBCT scanners with different Field of views -small, medium & large.

The use of CBCT technology in clinical practice provides the number of potential advantages for maxillofacial imaging compared with conventional CT[24]:

- ***X-ray beam limitation:*** Reducing the size of the irradiated area by collimation of the primary x-ray beam to the area of interest minimizes the radiation dose. Most CBCT units can be adjusted to scan small regions for specific diagnostic tasks. Others are capable of scanning the entire craniofacial complex when necessary.
- ***Image accuracy:*** The volumetric data set comprises a 3D block of smaller cuboid structures, known as voxels, each representing a specific degree of x-ray absorption. The size of these voxels determines the resolution of the image. In conventional CT, the voxels are anisotropic — rectangular cubes where the longest dimension of the voxel is the axial slice thickness and is determined by slice pitch, a function of gantry motion. Although CT voxel surfaces can be as small as 0.625 mm square, their depth is usually in the order of 1–2 mm. All CBCT units provide voxel resolutions that are isotropic — equal in all 3 dimensions. This produces sub-millimetre resolution (often exceeding the highest grade multi-slice CT) ranging from 0.4 mm to as low as 0.125 mm (Accuitomo).
- ***Rapid scan time:*** Because CBCT acquires all basis images in a single rotation, scan time is rapid (10–70 seconds) and comparable with that of medical spiral CT systems. Although faster scanning time usually means fewer basis images from which to reconstruct the volumetric data set, motion artifacts due to subject movement are reduced.
- ***Dose reduction:*** Published reports indicate that the effective dose of radiation (average range 36.9–50.3 microsievert [μSv] is significantly reduced by up to

98% compared with "conventional" fan-beam CT systems (average range for mandible 1,320–3,324 μSv; average range for maxilla 1,031–1,420 μSv). This reduces the effective patient dose to approximately that of a film-based periapical survey of the dentition (13–100 μSv) or 4–15 times that of a single panoramic radiograph (2.9–11 μSv).

- ***Display modes unique to maxillofacial imaging:*** Access and interaction with medical CT data are not possible as workstations are required. Although such data can be "converted" and imported into proprietary programs for use on personal computers (e.g., Sim/Plant, Materialise, Leuven, Belgium), this process is expensive and requires an intermediary stage that can extend the diagnostic phase. Reconstruction of CBCT data is performed natively by a personal computer. In addition, software can be made available to the user, not just the radiologist, either via direct purchase or innovative "per use" licence from various vendors (e.g., Imaging Sciences International). This provides the clinician with the opportunity to use chair-side image display, real-time analysis and MPR modes that are task specific. Because the CBCT volumetric data set is isotropic, the entire volume can be reoriented so that the patient's anatomic features are realigned. In addition, cursor-driven measurement algorithms allow the clinician to do real-time dimensional assessment.
- ***Reduced image artifact:*** With manufacturer's artifact suppression algorithms and increasing number of projections, our clinical experience has shown that CBCT images can result in a low level of metal artifact, particularly in secondary reconstructions designed for viewing the teeth and jaws.

Specific applications CBCT in dentistry: [24]

CBCT technology has a substantial impact on the maxillofacial imaging. It has been applied to diagnosis in almost all the areas of dentistry and now its role is also expanding into treatment fields.

- **Implant site assessment-**

  CBCT has been playing a very important role in planning of dental implant placements. It provides cross sectional images of the alveolar bone height, width and angulation and accurately shows the vital structures in the maxilla and mandible accurately and precisely. A diagnostic stent is made with radiographic markers and inserted at the time of scan. This also gives an exact reference of the location of the proposed implants.

- **Orthodontics and Three Dimensional Cephalometry-**

  CBCT provides clear-cut position of impacted and supernumerary teeth and their relationship to the adjacent teeth and neighbouring anatomical structures. Also added information regarding dimensions and morphological features, tooth inclination and torque, resorption of root and available alveolar bone width for bucco-lingual movement of teeth can be gained.

- **Temporomandibular joint-**

  CBCT provides multiplanar and 3 dimensional images of the condyle and surrounding structures to facilitate analysis and diagnosis of bone morphologic features, joint space. It can illustrate the features of degenerative joint disease, developmental anomalies of the condyle, ankylosis, and rheumatoid arthritis disease etc.

- **Conditions of the maxillofacial complex-**

  CBCT can assist in assessment of many conditions of the jaws such as supernumerary teeth, fractures or split teeth, periodontal and periapical diseases. Benign calcifications (e.g., tonsilloliths, lymph nodes, salivary gland stones) can also be identified by location and differentiated from potentially significant complications of the arteries such as carotid artery calcifications or veins (e.g., phleboliths). CBCT has been valuable for trauma and for assessing the extent and degree of involvement of osteomyelitis.

Albert DG et al conducted a study in 2006 and did comparative analysis between impacted mandibular third molars and mandibular canal by Orthopantomogram (OPG) and Conventional tomography. Nineteen patients were included in the study with impacted mandibular 3^{rd} molars bearing close relationship to the mandibular canal and were analyzed with OPG and Conventional tomography. In conventional tomography, 77.4% showed close relation with mandibular canal. In 92.1% of the cases, confirmation of true relationship was done in conventional tomography. Conclusion was given that the presence of the radiographic sign of a close relationship obtained in the OPG, most cases elicited a true relationship which further required the classification of the type of radiographic sign for the prevention of nerve injury.[53]

Neugebauer J et al conducted a study in 2008 and said that the removal of mandibular third molars needed information about the relative position of the tip of the root and the inferior alveolar nerve. Comparison was done using panoramic radiograph (PAN) and PA cephalometric radiograph (PA) under conventional radiologic techniques and cone beam volumetric imaging (CBVI) and the diagnostic value was evaluated. Evaluation was done by six observers of 30 PAN and PA and 30 CBVI for the position of the tip of the root and rating was performed from 1 to 5 (excellent to poor) of the diagnostic information. It was observed that in the vertical dimension median rating received the score of 2 (good) for CBVI and for PAN&PA; for the horizontal dimension, CBVI got the median rating of 2 (good), PAN and PA got significantly worse median rating of 3 (sufficient). The variability was high for the horizontal dimension with PAN and PA. Conclusion was that the CBVI improved the localization of mandibular third molar for surgical planning of removal of third molars.[54]

Nakagawa Y et al conducted a study in 2002 and evaluated the preoperative diagnostic utility of Dental three-dimensional (3D)-CT before minor oral surgical procedures. The 42.7 mm-high and 30 mm-wide rectangular solid images was provided by Dental 3D-CT. Clear demonstration of lesions in the maxillary and mandibular bone was shown by Dental 3D-CT. Resorption of the bone was revealed more clearly in the Dental 3D-CT compared to Conventional radiographs. Information about location of the lesion and the relationship between the lesion and neighbouring anatomical structures like mandibular canal and maxillary antrum, was very useful for execution of minor oral surgical procedures. Dental 3D-CT was proved to be very useful tool for preoperative evaluation before surgical procedures due to its added advantages of high resolution and low radiation dose.[55]

Ghaeminia H et al conducted a study in 2011 and assessed the utility of cone beam computed tomography (CBCT) in the planning of treatment of mandibular impacted third molars having high risk of injury to inferior alveolar nerve (IAN). Patients with the high risk of IAN injury, as assessed on panoramic radiographs, were included in the study and further additional CBCT imaging was taken for all the patients. Planning of the surgical procedure was done by two oral surgeons and the risk assessment of IAN injury in panoramic radiographs and in CBCT images was performed. The sample consisted of 40 patients having mean age 27.6 years with 53 impacted mandibular third molars. Statistical analysis showed significant result ($P<0.005$) of risk assessment for IAN injury on the basis of panoramic radiographs compared with CBCT images. After assessing the CBCT images, more patients were reclassified to a lower risk for IAN injury after the panoramic radiographic evaluation. This change in risk assessment also resulted in the modification of the surgical technique with statistical significance ($P<0.03$). This study concluded that CBCT contributes to better risk assessment and hence, more optimal surgical planning as compared with panoramic radiography.[56]

Nakayama K et al did a study in 2009 to evaluate the ability of dental 3-dimensional computed tomography to analyze and predict the exposure and injury to the inferior alveolar nerve (IAN) after mandibular third molar removal. Removal of 1,853 mandibular third molars in 1,539 patients was performed. Dental 3D-CT was done for 53 third molars in 47 patients among them. In 35 cases (66%), mandibular third molars were analyzed to assess the contact with the mandibular canal on dental 3D-CT images. On dental 3D-CT intraoperative IAN exposure was seen in 17 (49%) contact cases whereas in 2 (11%) noncontact cases on dental 3D-CT images. Removal of mandibular third molars done in 53 cases in whom dental 3D-CT examinations was done, IAN injury was seen in 8 cases (15%). IAN injury following IAN exposure was seen in 36.8% of the cases whereas IAN injury without IAN exposure was seen only in 2.9% of the cases. IAN injury incidence was 23% in the third molar-mandibular canal contact cases was 23% and all the 8 cases with IAN injury (100%) were third molar-mandibular canal contact type. It was concluded that contact of IAN and mandibular third molar root apices in dental 3D-CT predicts an increased risk for IAN exposure or injury.[57]

Susarla SM et al conducted a study in 2007 to evaluate the role of preoperative computed tomography (CT) imaging of the inferior alveolar nerve (IAN) preoperatively for the cases having high risk for IAN injury while mandibular third molar (M3) removal. Sample was consisted of patients who reported for M3 extraction and had been predicted as an increased risk for inferior alveolar nerve injury in panoramic radiograph. CT imaging was done preoperatively for all patients to assess the position of IAN in relation to M3.The predictor variable was preoperative risk assessment of IAN injury in panoramic radiograph and outcome variable was preoperative risk assessment of IAN injury in CT imaging. The number of IAN injuries was documented. Descriptive statistics were computed. The sample was composed of 23 patients having bilaterally impacted M3 age group ranging from 18-48 years. After assessing the panoramic radiographic, 80.4% of M3s were classified as high risk for IAN injury. After assessment of the CT images, 32.6% were classified as high risk for IAN injury. After analysis of all imaging findings, 71.7% of the teeth were removed. Intraoperative IAN visualization was seen in 21.2% of the cases. 3 patients reported with dysesthesia (9.1%) 1 week postoperatively moreover none had the permanent nerve injury. So it was that additional valuable information provided by CT imaging led to the modification of applied surgical approach and hence converted high risk IAN injury to low risk IAN injury.[58]

Flygare L et al conducted a study in 2008 to critically review the role of radiographic imaging prior to mandibular third molar extraction and to propose a strategy for preoperative imaging on basis of available scientific evidences as well as clinical experience. From the Medline database, original articles and reviews which encompassed the MESH terms "third molar" and "radiography" were chosen. It was found that the scientific literature and evidences on the preoperative imaging methods of mandibular third molar teeth were low. Therefore, information collected from the literature resources was combined with the author’s clinical experience. It is suggested that intraoral and panoramic radiograph are sufficient as preoperative imaging in the cases where there is no overlap or close relationship between the mandibular canal and the mandibular third molar and in addition, posteroanterior open mouth projection will be sufficient for the remaining cases whereas in cases showing intimate or close relationship between the mandibular canal and the mandibular third molar, indication of cone beam computed tomography or low-dose computed tomography is present.[59]

Tantanapornkul W et al conducted a study in 2007 to analyze and assess the diagnostic accuracy of cone-beam CT compared with panoramic images in prediction of neurovascular bundle exposure during removal of impacted mandibular third molars. 142 impacted mandibular third molars were evaluated on panoramic radiograph and cone beam CT to assess the relationship of tooth to the mandibular canal. These radiographic findings were correlated with intraoperative findings. The calculation of sensitivity and specificity of both the imaging techniques was done for the prediction of neurovascular bundle exposure. The sensitivity and specificity of cone beam CT were 93% and 77% and 70% and 63% for panoramic images, respectively. So, it was concluded that cone beam CT was significantly superior in assessing and predicting neurovascular bundle exposure to panoramic radiograph prior to the extraction of impacted mandibular third molar.[60]

Suomalainen A et al conducted a study in 2010 with the aim to compare the reliability of cone-beam computerized tomography (CBCT) and other radiographic techniques to determine number of roots of mandibular third molar and their relationship to inferior alveolar canal (IAC) preoperatively. Forty-two teeth were enrolled in the study and were imaged using CBCT and other imaging modalities which were panoramic imaging, multiprojection narrow-beam radiography (MNBR), and cross-sectional tomography. Diagnosis of two oral radiologists and radiologic diagnosis at operation were compared using kappa values as statistical analysis. Cone-beam CT was more reliable than panoramic radiograph in showing number of roots of mandibular third molar. CBCT images were highly reliable in localization of IAC, whereas MNBR was not reliable and cross-sectional tomography showed results between the two. IAC could not be interpreted in one-third of the cases using cross sectional tomography. So, it was concluded the CBCT was preferred and recommended for preoperative radiographic evaluation of complicated cases.[61]

Miloro M et al conducted a study in 2005 to detect the distance from the mandibular third molar to the inferior alveolar canal using panoramic radiograph. Assessment of 560 mandibular third molars was done using panoramic radiography. The teeth were categorized into erupted and unerupted and were further subdivided depending upon the tooth angulation. The measurement of distance from the most inferior aspect of mandibular third molar to the superior border of IAC was done using digital caliper device. A “t” test was done to compare erupted and unerupted teeth, and ANOVA was done to detect difference based upon tooth angulation. A review based on records was done to evaluate the inferior alveolar nerve paresthesia incidence on the basis of measured distances. The mean distance was 0.88mm from erupted mandibular third molar to the inferior alveolar canal and was significantly different from unerupted teeth (P=.002). The most inferior portion of the teeth was below the superior border of IAC for unerupted teeth suggested by the mean values as follows: vertical (-0.61mm), mesioangular (-0.97mm), distoangular (-0.31mm) and horizontal (-0.24). It was also found that mesioangular impaction (-0.66mm) was most commonly associated with inferior alveolar nerve paresthesia. It was concluded from the study that mesioangular mandibular third molar impactions were most closely related and positioned to the inferior alveolar canal, and it may represent an independent risk factor for postoperative paresthesia.[62]

Szalma J et al conducted a case-control study in 2010 to assess the accuracy of panoramic radiographic signs in prediction of inferior alveolar nerve (IAN) paresthesia after mandibular third molar removal. The sample was consisted of 41 cases with postoperative IAN paresthesia and 359 control cases with no postoperative IAN paresthesia. The gathered data included "classic" specific signs indicating the intimate relationship between mandibular third molar root and inferior alveolar canal (IAC), curvature of roots, and also the extent of IAC-root tip overlapping. It was found that 3 specific signs were significantly associated with IAN paresthesia ($P < .001$) and they were interruption of the superior cortex of the canal wall, darkening of root, and diversion of the canal. The range of sensitivities and specificities varied from 14.6% to 68.3% and from 85.5% to 96.9%, respectively. This study concluded that for screening, panoramic radiograph was not sufficient for prediction of IAN injury and postoperative paresthesia after mandibular third molar extraction.[63]

Blaeser BF et al conducted a case-control study in 2003 to assess the association between specific panoramic radiographic signs and inferior alveolar nerve (IAN) injury during mandibular third molar extraction. Subjects who all underwent extraction of mandibular third molar were only included in the study. Sample was composed of 8 cases and 17 controls. Patients with confirmed IAN injury after third molar removal were designated as cases, whereas patients without IAN injury after third molar extraction were designated as controls. Preoperative panoramic radiographs for the presence of high risk radiographic signs were assessed by five surgeons who were blinded to the injury status. The sensitivity, specificity, and positive and negative predictive values were calculated for each radiographic sign. Statistical significant association was shown between positive radiographic signs and IAN injury with P value <0.0001. This study confirmed the previous studies analyses stating that panoramic findings of diversion of the inferior alveolar canal, interruption of the cortical white line, and darkening of the third molar root were statistically associated with IAN injury. This study also consolidated that the minimal risk of nerve injury was associated with the absence of positive radiographic findings, whereas presence of one of these positive radiographic finding was associated with an increased risk of nerve injury.[64]

Sedaghatfar M et al conducted a study in 2005 to evaluate the sensitivity and specificity of panoramic radiographic findings in respect to inferior alveolar nerve (IAN) exposure after mandibular third molar (M3) removal. The study design was retrospective cohort model. The presence or absence of greater or equal to one panoramic radiographic signs associated with an increased risk of IAN injury was used as the primary predictor value whereas surgeon's assessment of IAN exposure risk was used as the secondary predictor values. IAN exposure which means the direct visualization of IAN during mandibular third molar extraction was used as outcome variable. The sample was consisted of 423 mandibular M3s evaluated and extracted. IAN exposure was seen in 24 (5.7%) extraction sites following the mandibular M3 removal. It was also found that the four radiographic signs (darkening of root, interruption of white line, diversion of the canal, and narrowing of the root) were statistically associated with IAN exposure following mandibular M3 removal (P < or = .05). The clinicians preoperative prediction of the likelihood of exposure of IAN was statistically associated with exposure of IAN after M3 removal with P value < .001, sensitivity = 0.79, specificity = 0.86). It was also found that risk of IAN exposure intraoperatively was statistically associated with the estimated IAN exposure risk on panoramic radiograph.[65]

Susarla SM et al conducted a study in 2010 to assess the association between inferior alveolar nerve (IAN) canal cortical integrity and IAN exposure intraoperatively in computed tomography (CT). The study was a retrospective cohort model. The patients diagnosed as high risk for IAN injury on panoramic radiograph were enrolled in the study. The sample consisted of 51 subjects having 80 third molars.IAN canal integrity indicated as intact or interrupted evaluated on coronal CT images was used as primary predictor variable and length of cortical defect in millimeters was used as secondary predictor variable. Intraoperative visualization of IAN was used as primary outcome variable.52 third molars (64.1%) out of 80 third molars showed the evidence of loss of cortical integrity of IAC. 2.9 +/- 2.6 mm was the mean cortical defect length. The length of cortical defect > or = 3 mm was shown to be associated with high risk of IAN visualization intraoperatively with the both high sensitivity as well as specificity (> or = 0.82). It was concluded that for the prediction of IAN exposure intraoperatively, cortical defect size evaluated on CT images showed high sensitivity and specificity.[66]

Jerjes W et al conducted a retrospective study in 2006 to assess the relationship between preoperative panoramic findings and postoperative inferior alveolar nerve paresthesia after mandibular third molar removal, and also to evaluate the surgical difficulty. Two groups of patients were randomly selected. Patients presented with IAN paresthesia after mandibular third molar removal were included in first group and patients presented with no complication of IAN paresthesia were include in second group. Radiological findings were gathered from the panoramic radiographs of these patients and were compared to postoperative paresthesia. The degree of surgical difficulty was also evaluated radiographically. Parameters like type of impaction (fully impacted), ramus/space (class 3), depth of impaction (depth C), spatial relationship (distoangular and horizontal), shape of root (thick and incomplete), number of roots (multiple and incomplete), shape of the tip of root (curved and incomplete), and relation to IAN (touching, superimposed, or non-specific) were highly significant ($p < 0.001$) in predicting the incidence of paresthesia.

It was also stated that where lower third molar is > or = 1 mm from IAC, 98% there is no probability of numbness but in cases where tooth is in contact with IAC, probability of paresthesia is 60%. Statistics also showed that interruption of white line of IAC has 54% probability of paresthesia, narrowing of root has 87% probability of paresthesia, diversion of canal has 60% probability of paresthesia, and darkening of root has 42% probability of paresthesia. So it was concluded that factors depth of impaction, ramus relationship/space available, spatial relationship, number and shape of roots, and relation of the root to the IAN can help in assessing surgical difficulty of mandibular third molars radiographically.[67]

Park W et al conducted a retrospective study in 2010 to assess the relationship between paresthesia following mandibular third molar (MTM) removal and the cortical integrity of the inferior alveolar canal (IAC) by means of computed tomography (CT). Subjects were selected on the basis of panoramic radiographic finding of high risk of injury to inferior alveolar nerve. All these subjects subsequently underwent CT imaging also and extraction of MTM. Contact relationship between the IAC and the MTM as assessed on the CT image was used as primary predictor variable and were further categorized into three groups: group 1showing no contact; group 2 showing contact between the MTM and the intact IAC cortical lining; group 3 showing contact between the MTM and the interrupted IAC cortical lining. The number of CT image sections showing the cortical interruption of IAC was taken as secondary predictor variable. The outcome variable assessed was the absence or presence of postoperative paresthesia following MTM removal. The sample consisted of 179 subjects who underwent 259 MTM removals. The overall prevalence of paresthesia was found to be 4.2 percent (11 of 259 teeth). The maximum prevalence of paresthesia was shown by group 3 which was 11.8 percent, while for group 2 showed 1% and group 1 showed 0%. Statistical significant results were found between frequency of inferior alveolar nerve damage and the number of CT sections showing loss of cortical integrity of IAC (P value=0.043). So it was concluded that the loss cortical integrity of IAC was associated with an increased risk of paresthesia following MTM surgery.[68]

Palma-Carrió C et al conducted a study in 2010 with the aim of literature review of preoperative radiographic signs in orthopantomogram (OPG) and computed tomography (CT) associated with the risk of inferior alveolar nerve injury during the surgical removal of lower third molar (LTM). PubMed search was done for the literature evidences published between the years 2000 and 2009. Among the reviewed literatures, radiographic signs in the OPG which indicates a close relationship between the LTM and the inferior alveolar canal were taken into consideration as the risk factors for the inferior alveolar nerve damage. These signs were darkening and deflection of the root, and interruption and diversion of the white line of the mandibular canal. The regular routine use of CT is not justified in all the cases, and is only indicated in the cases where radiographic signs in the OPG demonstrate a close anatomical relationship between the LTM and the mandibular canal. CT showing the absence of cortical lining of the mandibular canal denotes the contact between the root of the LTM and the mandibular canal, and is also related with the presence of some specific radiographic signs in the OPG.[69]

W Tantanapornkul et al conducted a study in 2009 to assess that darkening of the mandibular third molar root in panoramic radiograph is known to indicate the close and intimate relationship between the root and mandibular canal. 253 impacted mandibular third molars were assessed in the study. Imaging evaluation was done of both digital panoramic radiography and cone beam CT. Panoramic images were assessed to determine the presence or absence of darkening of the apical part of root of mandibular third molar. Cone beam CT images were evaluated for the following two findings: (1) grooving of the root and (2) thinning or perforation of the cortical plate by the root. Panoramic finding of darkening of the root was shown by 80 impacted mandibular third molars out of 253 impacted mandibular third molars. Cone beam CT finding of cortical thinning or perforation was significantly correlated with the darkening of root as panoramic finding (80%, P, 0.001). So conclusion was given that panoramic finding of darkening of roots depicts cortical plate thinning or perforation in cone beam CT.[70]

F Sampaio Neves et al conducted a study in 2012 to evaluate the reliability of four panoramic radiographic findings (darkening of roots, narrowing of mandibular canal, diversion of mandibular canal, and interruption of white line) in prediction of the absence of corticalization between the mandibular canal and the mandibular third molar on cone beam (CB) CT images. The sample was composed of 142 mandibular third molars who underwent preoperative radiographic assessment prior to removal of impacted mandibular third molars. It was found that darkening of root and interruption of white line of mandibular canal on panoramic radiograph was significantly associated with absence of corticalisation of mandibular canal in CBCT images (P value <0.05)No statistically significant association was observed for the other panoramic radiographic findings, either individually or in association (P>0.05). This study concluded that darkening of roots and interruption of white line observed on panoramic radiograph requires further 3 dimensional evaluation of relationship between mandibular canal and impacted mandibular third molar to predict the risk of IAN injury during mandibular third molar surgery.[71]

MATERIALS AND METHODS

The study was conducted at

- Department of Oral Medicine and Radiology,

  Tamil Nadu Government Dental College and Hospital,

  Chennai – 600 003.

- Aarthi scans,

  60, 100 feet road, Vadapalani,

  Chennai – 600 026.

The study protocol was approved by the Institutional Ethical Committee.

Duration of the study: From May 2012 to November 2012 (7 months)

Sample design:

Totally 20 patients were included under the study. The cases reported with impacted lower third molars for routine investigation and treatment were selected from the Department of Oral Medicine and Radiology, Tamil Nadu Government Dental College and Hospital, Chennai – 600 003 between May and November 2012. All were in the age group of 22 – 30 years (mean age = 26 years) of either gender. A total of 40 impacted teeth were assessed in this study.

Design of the study: A prospective study

Consent: An informed consent was obtained from all the patients participating in the study.

Inclusion criteria:

- Patients having age group ranging from 22 to 30 years (mean age = 26 years) of either gender.
- Presence of one or both impacted mandibular third molar.
- Patients who are willing and able to attend throughout radiographic assessment.

Exclusion criteria:

- Uncooperative patients
- Patients reporting with maxillofacial trauma
- Patients suffering from severe physical and/ or mental disability
- Pregnant patients
- Unwilling to participate in the study

Clinical and radiological criteria for diagnosis of impacted teeth:

- Partially/Completely unerupted permanent teeth even after normal eruptive age.
- Radiographic evidence of partially/completely unerupted fully developed teeth.

Armamentarium:

- Disposable gloves
- Face mask
- Patient's apron
- Stainless steel tray
- Mouth mirror
- Tweezer
- Probe

- Gauze

Thorough clinical examination was done in all the patients. There are several radiographic signs in panoramic radiograph which are considered as risk factors for injury to inferior alveolar nerve such as darkening of roots, interruption of white line of mandibular canal, narrowing of mandibular canal, superimposition of roots on mandibular canal, deviation of mandibular canal, and combination of these findings.[13,17,25,26] Patients having one of these radiographic signs as diagnosed in panoramic radiograph were only included in the study. Further, all these patients were subjected to the additional CBCT evaluation. The panoramic findings were also evaluated and confirmed in CBCT reformatted panoramic images. Cross sectional CBCT images were evaluated for bucco-lingual position of mandibular canal, supero-inferior position of mandibular canal, absence or presence of corticalisation of mandibular canal, and cortical plate perforation.

<u>Panoramic radiograph:</u>

Kodak 8000C digital panoramic and cephalometric system was used to obtain panoramic radiograph. Scanning parameters were 12mA, 73kV and 13.9 seconds scanning time. Before the exposure, patients were advised to remove dental appliances, earrings, necklaces, hairpins or any other metallic objects in the head and neck region if any. The correct antero-posterior positioning was achieved by making the patient to keep the maxillary and mandibular incisors into the notch of the bite block. The patient head was then positioned properly in all the three orthogonal planes and exposure was made. Patient positioning was standing position while taking the scan.

<u>Cone beam computed tomography (CBCT):</u>

KODAK 9500 cone beam 3D Extraoral imaging system with a reconstruction volume of 50x37mm and a reconstructed matrix voxel of 76.5x76.5x76.5µm was used to obtain the CBCT images. The equipment has CMOS sensor technology. Exposure parameters for the patients varied from 90 kV, 10 mA with a scan time of 10.8 seconds. Patients were positioned in standing position while taking the scan. The total image acquisition time was less than 2 minutes. The impacted teeth were assessed by the 3 D volumetric image and 1 mm tomographic sections in sagittal, axial and coronal planes. The field of view was 9 x 15cm (from the bottom of the chin to the top of the jaw). Tomographic sections were taken in curved planar reformation (panorex), a series of multiplanar reconstructions (cross sections).

Curved planar reformation: This is a type of multiplanar reformation accomplished by aligning the long axis of the imaging plane with a specific anatomic structure (arch form).[24] This mode was useful in displaying the dental arch, providing familiar panoramic like thin-slice images, which were useful to study inferior alveolar canal in contact with impacted third molar.

Basic enhancements included zoom or magnification and visual adjustments to narrow the range of displayed grey-scales (window) contrast level within the window to annotations and cursor-driven measurements.[24]

<u>Radiation exposure:</u>

Single Panoramic radiograph – 2.9 to 11 µSv.[27,28]

Single CBCT scan – 36.9 to 50.3 µSv.[23,29,30]

The radiographic exposure for patients was well below the maximum permissible dose of 2.4 mSv as per the NCRP guidelines.[31]

Radiation safety precautions such as filtration, collimation, and patient protection equipments like thyroid collar, lead apron, and gonadal shield were used before subjecting the patients for imaging evaluation.

PHOTOGRAPHS

ARMAMENTARIUM

DIAGNOSTIC INSTRUMENTS

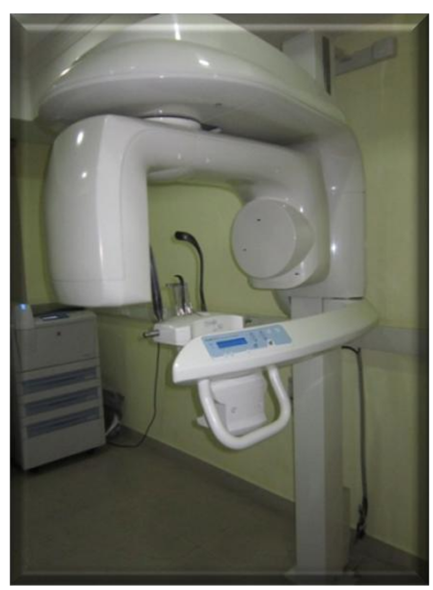
FIGURE 1

PANOREX MACHINE

FIGURE 2

CBCT MACHINE

FIGURE 3



PATIENT POSITIONING IN PANOREX MACHINE

FIGURE 4

PATIENT POSITIONING IN CBCT MACHINE

FIGURE 5

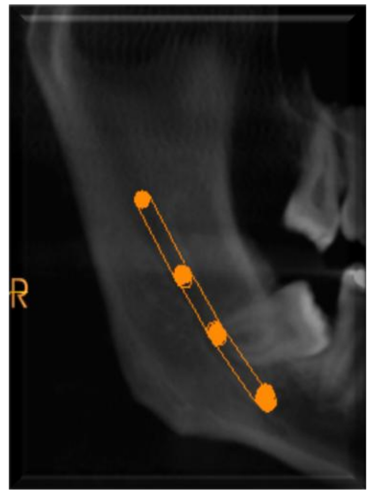
CLINICAL CASES

INTERRUPTION OF WHITE LINE

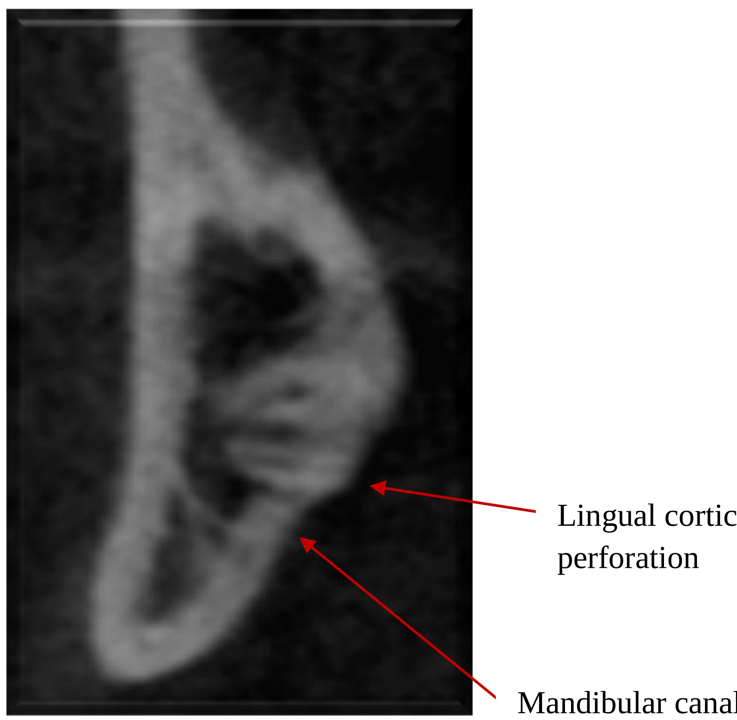
Photograph showing partially erupted 48

Cropped panoramic radiograph showing mesioangularly impacted 48 at level C showing interruption of white line

Cropped CBCT reformatted panoramic image showing mesioangularly impacted 48 at level C, interruption of white line



Cropped CBCT reformatted panoramic image showing marked outline of mandibular canal



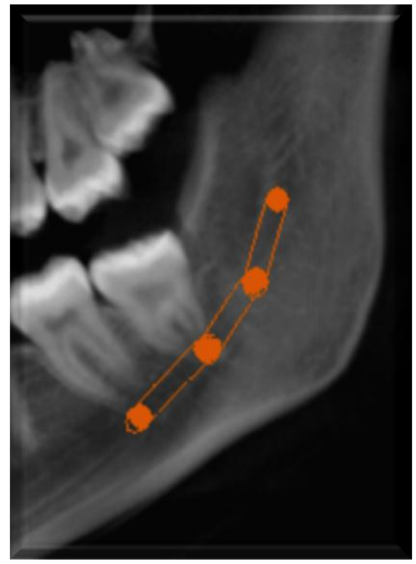
Coronal section of CBCT showing mandibular canal in vertical plane present inferior to the roots, in horizontal plane present at tle level of roots, absence of corticalisation of mandibular canal, and lingual cortical plate perforation

SUPERIMPOSITION OF ROOTS ON MANDIBULAR CANAL

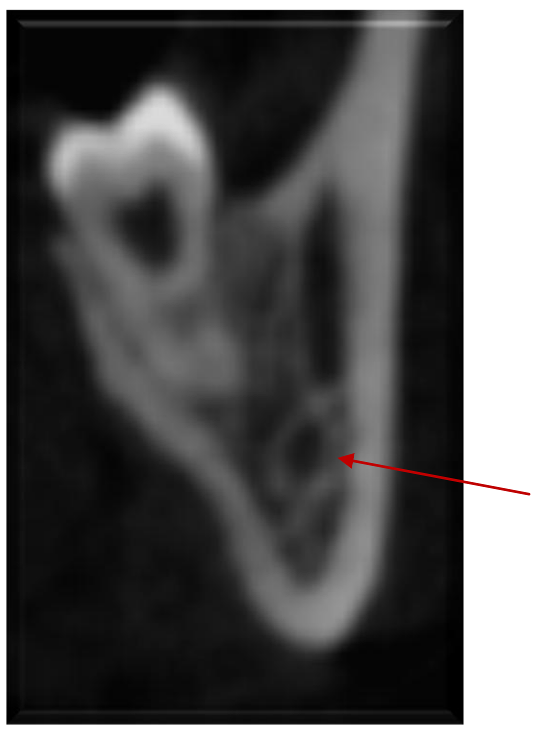
Photograph showing partially erupted 38

Cropped Panoramic radiograph showing vertically impacted 38 at the level B showing superimposition of roots on mandibular canal

Cropped CBCT reformatted panoramic image showing vertically impacted 38 at the level B showing superimposition of roots on mandibular canal



Cropped CBCT reformatted panoramic image showing marked outline of mandibular canal



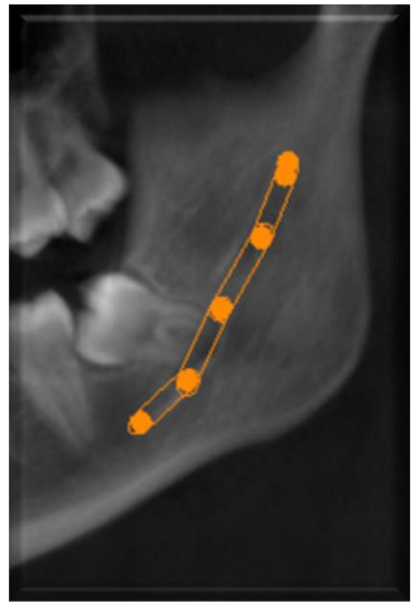
Coronal section of CBCT showing mandibular canal in vertical plane present inferior to the roots, in horizontal plane present buccal to the roots, presence of corticalisation of mandibular canal, and no cortical plate perforation

DARKENING OF ROOT

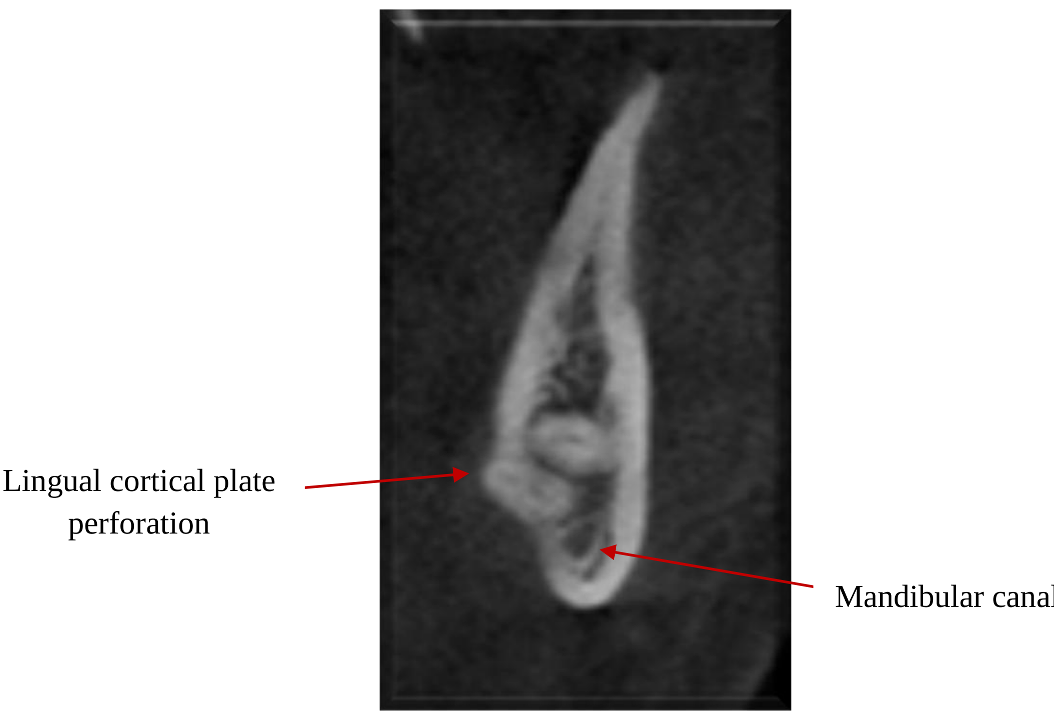
Photograph showing clinically unerupted 38

Cropped Panoramic radiograph showing mesioangularly impacted 38 at the level C showing darkening of apical part of roots

Cropped CBCT reformatted panoramic image showing mesioangularly impacted 38 at the level C showing darkening of apical part of roots



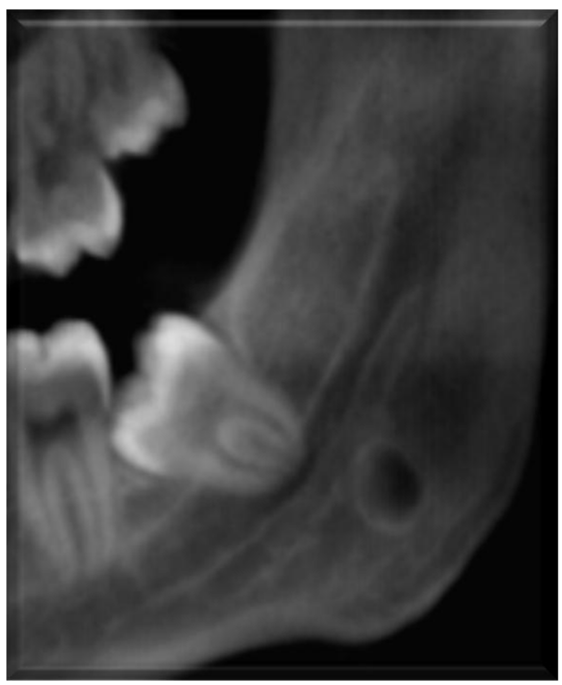
Cropped CBCT reformatted panoramic image showing marked outline of mandibular canal



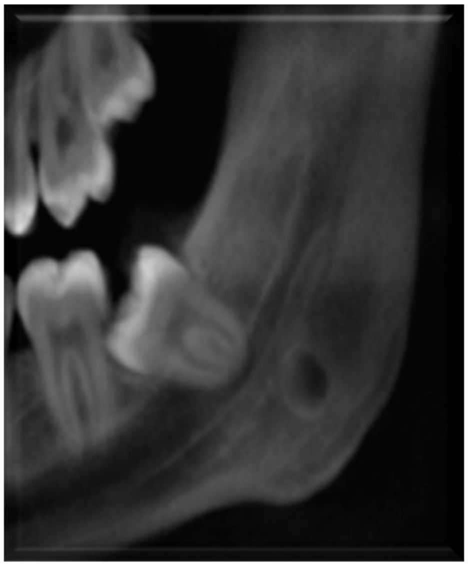
Coronal section of CBCT showing mandibular canal in vertical plane present inferior to the roots, in horizontal plane present at the level of roots, presence of corticalisation of mandibular canal, and lingual cortical plate perforation

NARROWING OF MANDIBULAR CANAL

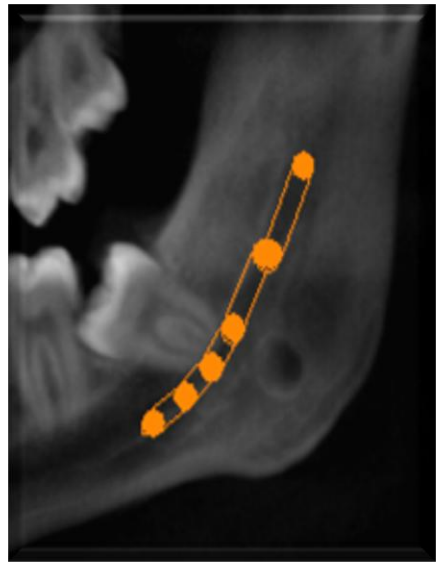
Photograph showing partially erupted 38



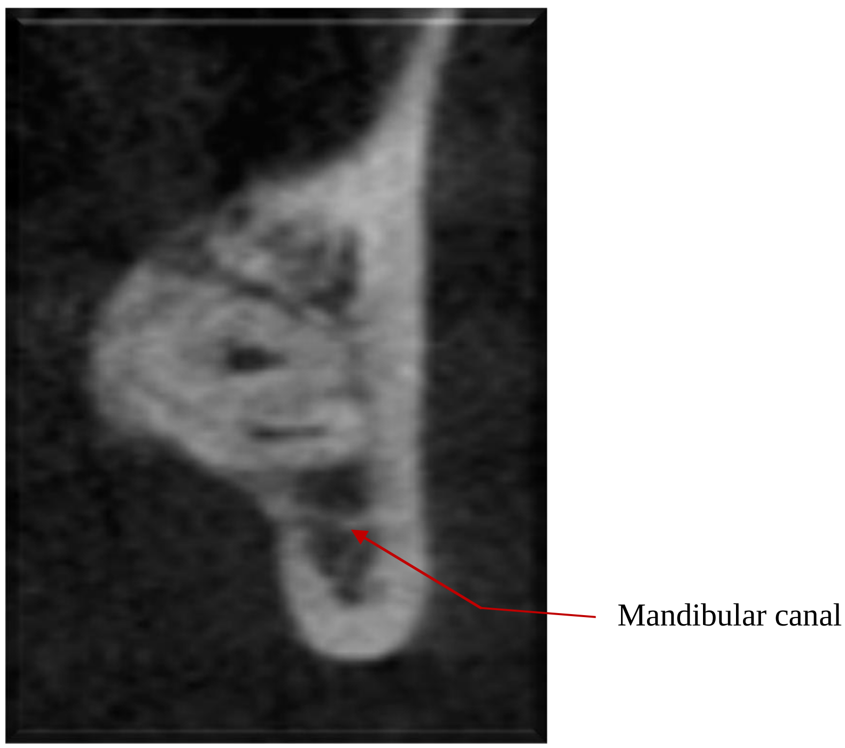
Cropped Panoramic radiograph showing mesioangularly impacted 38 at the level C showing narrowing of mandibular canal



Cropped CBCT reformatted panoramic image showing mesioangularly impacted 38 at the level C showing narrowing of mandibular canal



Cropped CBCT reformatted panoramic image showing marked outline of mandibular canal

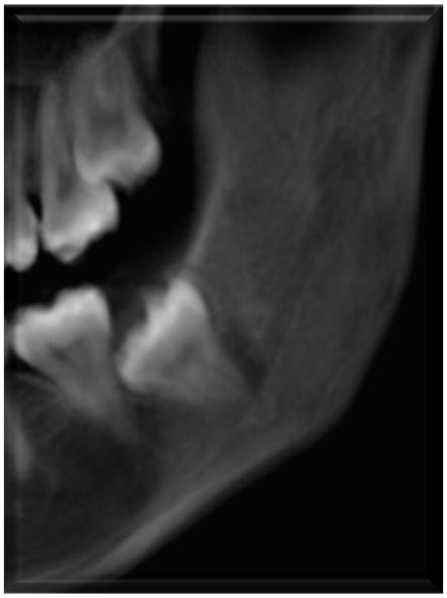


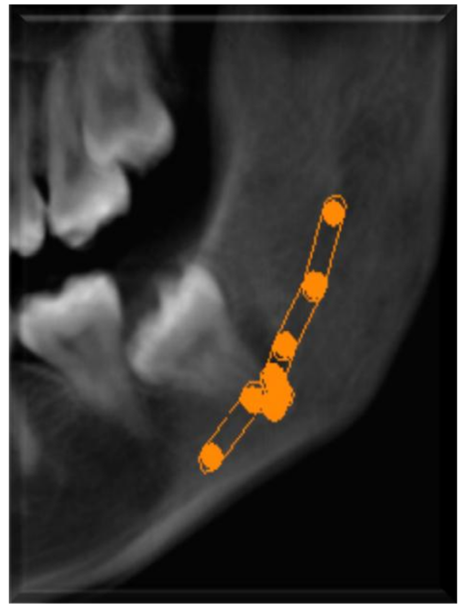
Coronal section of CBCT showing mandibular canal in vertical plane present inferior to the roots, in horizontal plane present at the level of roots, absence of corticalisation of mandibular canal, and no cortical plate perforation

DEVIATION OF MANDIBULAR CANAL + INTERRUPTION OF WHITE LINE

Photograph showing clinically unerupted 38

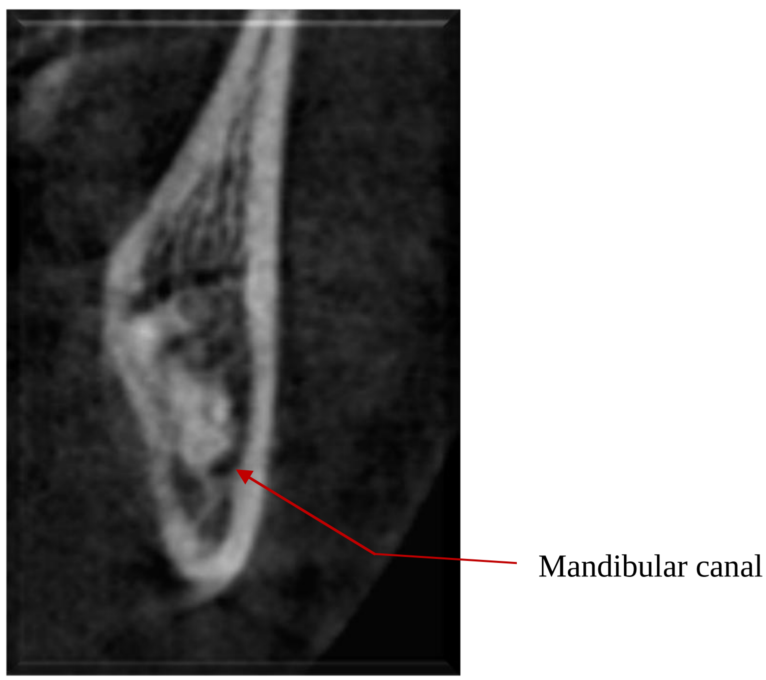
Cropped Panoramic radiograph showing mesioangularly impacted 38 at the level C showing deviation of mandibular canal + interruption of white line





Cropped CBCT reformatted panoramic image showing mesioangularly impacted 38 at the level C showing deviation of mandibular canal + interruption of white line

Cropped CBCT reformatted panoramic image showing marked outline of mandibular canal



Coronal section of CBCT showing mandibular canal in vertical plane present inferior to the roots, in horizontal plane present at the level of roots, absence of corticalisation of mandibular canal, and no cortical plate perforation

<u>**RESULTS**</u>

STATISTICAL ANALYSIS

The statistical analysis was done using the computer software program SPSS version18.

Values were analyzed using descriptive and analytical statistics.

Fisher's Exact test was used to evaluate the correlation between various panoramic findings and CBCT findings.

In the present study, ***P-value <0.05*** was considered as the level of significance.

MASTER CHART

SERIAL NO.	AGE	SEX	ANGULATION	DEPTH	PANORAMIC SIGN	B-L CANAL POSITION	S-I CANAL POSITION	CANAL CORTICALISATION	CORTICAL PLATE PERFORATION
1.	22	M	Mesioangular	Level C	IWL	At roots level	Inferior	Absent	Present
			Mesioangular	Level C	IWL	At roots level	Inferior	Absent	Present
2.	24	F	Vertical	Level B	DR	Lingual	At roots level	Present	Present
			Vertical	Level B	IWL	Lingual	Inferior	Absent	Present
3.	24	F	Distoangular	Level A	SMC	Buccal	Inferior	Present	Absent
			Distoangular	Level A	IWL	Buccal	Inferior	Present	Absent
4.	27	F	Vertical	Level A	NMC	At roots level	Inferior	Absent	Present
			Vertical	Level A	IWL	Buccal	Inferior	Present	Absent
5.	22	F	Mesioangular	Level C	NMC	At roots level	Inferior	Absent	Absent
			Vertical	Level A	IWL	Buccal	At roots level	Absent	Absent
6.	22	M	Vertical	Level A	IWL	Buccal	Superior	Absent	Absent
			Mesioangular	Level B	IWL	Buccal	Superior	Absent	Absent
7.	22	F	Mesioangular	Level C	DMC + IWL	Buccal	Inferior	Absent	Absent
			Mesioangular	Level C	IWL	At roots level	Inferior	Absent	Absent
8.	25	F	Mesioangular	Level B	IWL	Lingual	Inferior	Absent	Absent
			Mesioangular	Level B	IWL	Lingual	Inferior	Absent	Absent
9.	23	F	Vertical	Level B	NMC	At roots level	Inferior	Absent	Absent
			Mesioangular	Level C	IWL	Lingual	At roots level	Absent	Present
10.	22	M	Vertical	Level A	IWL	At roots level	At roots level	Present	Absent
			Vertical	Level A	IWL	Lingual	At roots level	Absent	Absent
11.	25	F	Vertical	Level A	IWL	At roots level	Inferior	Absent	Absent
			Vertical	Level A	IWL	At roots level	Inferior	Absent	Absent
12.	22	M	Mesioangular	Level C	SMC	Buccal	Inferior	Present	Present
			Vertical	Level A	DR	At roots level	Inferior	Present	Absent
13.	22	F	Mesioangular	Level C	DR	Lingual	Inferior	Present	Present
			Mesioangular	Level C	DR	Lingual	At roots level	Present	Present
14.	30	M	Horizontal	Level C	IWC	At roots level	Inferior	Absent	Absent
			Mesioangular	Level C	NMC	At roots level	Inferior	Absent	Absent
15.	22	M	Vertical	Level A	IWL	At roots level	Inferior	Absent	Absent
			Vertical	Level B	DR	At roots level	Inferior	Present	Present
16.	22	F	Mesioangular	Level C	IWL	At roots level	Inferior	Absent	Absent
			Mesioangular	Level C	DR	Lingual	Inferior	Absent	Present
17.	22	M	Mesioangular	Level B	DR	At roots level	Inferior	Absent	Present
			Horizontal	Level C	IWL	Buccal	Inferior	Present	Present
18.	23	F	Vertical	Level B	SMC	Buccal	Inferior	Present	Absent
			Vertical	Level C	SMC	Buccal	Inferior	Present	Absent
19.	26	M	Mesioangular	Level C	DR	At roots level	Inferior	Present	Present
			Mesioangular	Level C	IWL	At roots level	Inferior	Absent	Absent
20.	22	M	Mesioangular	Level C	IWL	At roots level	Inferior	Absent	Absent
			Mesioangular	Level C	IWL	At roots level	Inferior	Absent	Absent

M= Male, F=Female

B-I = Bucco-lingual

S-I = Supero-inferior

IWL = Interruption of white line

DR = Darkening of roots

NMC = Narrowing of mandibular canal

SMC = Superimposition of roots on mandibular canal

DMC = Deviation of mandibular canal

Table 1: Position of impacted mandibular third molars determined in panoramic radiograph based on angulation[74]

Tooth position in bone	Number of cases (n=40)	%
Vertical	16	40
Mesioangular	20	50
Distoangular	2	5
Horizontal	2	5
Total	40	100

Table 2: Position of impacted mandibular third molars determined in CBCT reformatted panoramic image based on angulation after evaluation in panoramic radiograph[74]

Tooth position in bone	Number of cases (n=40)	%
Vertical	16	40
Mesioangular	20	50
Distoangular	2	5
Horizontal	2	5
Total	40	100

Table 3: Position of impacted mandibular third molars determined in panoramic radiograph based on depth[78]

Tooth position in bone	Number of cases (n=40)	%
Level A	12	30
Level B	9	22.5
Level C	19	47.5
Total	40	100

Table 4: Position of impacted mandibular third molars determined in CBCT reformatted panoramic image based on depth after evaluation in panoramic radiograph[78]

Tooth position in bone	Number of cases (n=40)	%
Level A	12	30
Level B	9	22.5
Level C	19	47.5
Total	40	100

Table 5: Number of patients showing similar type of impacted mandibular third molar both the sides based on angulation

Tooth position in bone	Number of patients
Vertical	6
Mesioangular	7
Distoangular	1
Horizontal	-

Table 6: Number of patients showing similar type of impacted mandibular third molar both the sides based on depth

Tooth position in bone	Number of patients
Level A	4
Level B	2
Level C	7

Table 7: Findings associated with high risk injury to inferior alveolar nerve in panoramic radiograph[13,17,25,26]

Radiographic finding	Number of cases (n=40)	%
DR	8	20
IWL	23	57.5
NMC	4	10
SMC	4	10
DMC	-	-
DMC + IWL	1	2.5
Total	40	100

DR = darkening of roots, IWL = interruption of white line, NMC = narrowing of mandibular canal, SMC = superimposition of roots on mandibular canal, DMC = deviation of mandibular canal

Table 8: Findings associated with high risk injury to inferior alveolar nerve in CBCT reformatted panoramic image after evaluation in panoramic radiograph[13,17,25,26]

Radiographic finding	Number of cases (n=40)	%
DR	8	20
IWL	23	57.5
NMC	4	10
SMC	4	10
DMC	-	-
DMC + IWL	1	2.5
Total	40	100

DR = darkening of roots, IWL = interruption of white line, NMC = narrowing of mandibular canal, SMC = superimposition of roots on mandibular canal, DMC = deviation of mandibular canal

Table 9: Bucco-lingual position of mandibular canal in relation to roots of impacted mandibular third molars determined in CBCT cross sectional images

Position of mandibular canal in CBCT	Number of cases (n=40)	%
Buccal	11	27.5
Lingual	9	22.5
At level of roots	20	50
Total	40	100

Table 10: Supero-inferior position of mandibular canal in relation to roots of impacted mandibular third molars determined in CBCT cross sectional images

Position of mandibular canal in CBCT	Number of cases (n=40)	%
Superior	2	5
Inferior	32	80
At level of roots	6	15
Total	40	100

Table 11: Evaluation of correlation of corticalisation of mandibular canal in CBCT cross sectional images associated with different panoramic radiograph signs

Panoramic findings(n=40)	Presence of corticalisation in CBCT	Absence of corticalisation in CBCT	P value
DR = 8 (20%)	6 (75%)	2 (25%)	<0.05
IWL = 23 (57.5%)	4 (17.3%)	19 (82.6%)	<0.05
NMC = 4 (10%)	0 (0%)	4 (100%)	>0.05
SMC = 4 (10%)	4 (100%)	0 (0%)	<0.05
DMC = 0 (0%)	-	-	-
DMC+IWL = 1 (2.5%)	0 (0%)	1 (100%)	>0.05

Table 12: Evaluation of correlation of cortical plate perforation in CBCT cross sectional images associated with different panoramic radiograph signs

Panoramic findings (n=40)	Cortical plate perforation in CBCT	P value
DR = 8 (20%)	7 (87.5%)	<0.05
IWL = 23 (57.5%)	5 (21.7%)	>0.05
NMC = 4 (10%)	1 (25%)	>0.05
SMC = 4 (10%)	1 (25%)	>0.05
DMC = 0 (0%)	-	-
DMC+IWL = 1 (2.5%)	-	>0.05

DR = darkening of roots, IWL = interruption of white line, NMC = narrowing of mandibular canal, SMC = superimposition of roots on mandibular canal, DMC = deviation of mandibular canal

Chart 1: Distribution of impacted mandibular third molars depending upon angulation

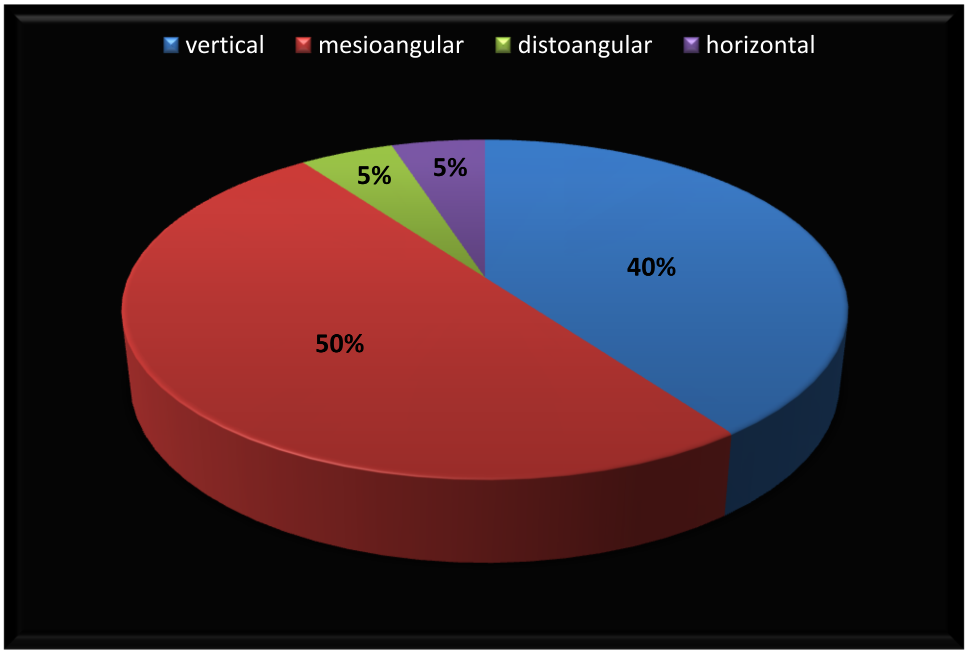


Chart 2: Distribution of impacted mandibular third molars depending upon depth

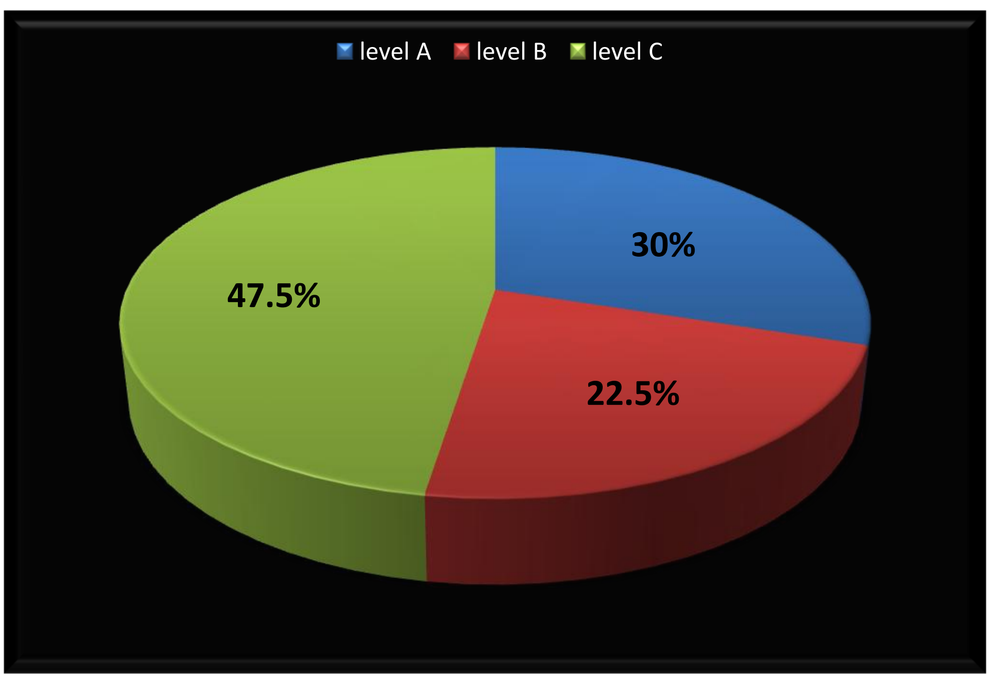
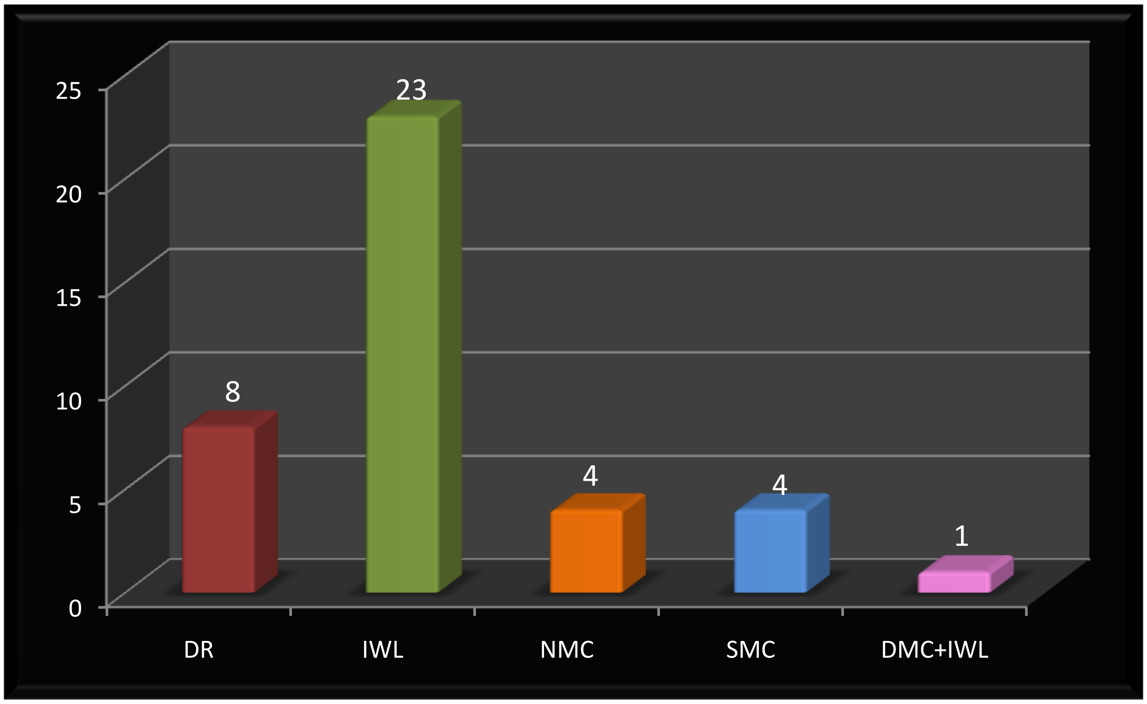


Chart 3: Distribution of different panoramic radiographic signs associated with high risk injury to inferior alveolar canal



DR = darkening of roots, IWL = interruption of white line, NMC = narrowing of mandibular canal, SMC = superimposition of roots on mandibular canal, DMC = deviation of mandibular canal

Chart 4: Distribution of bucco-lingual position of mandibular canal in CBCT images

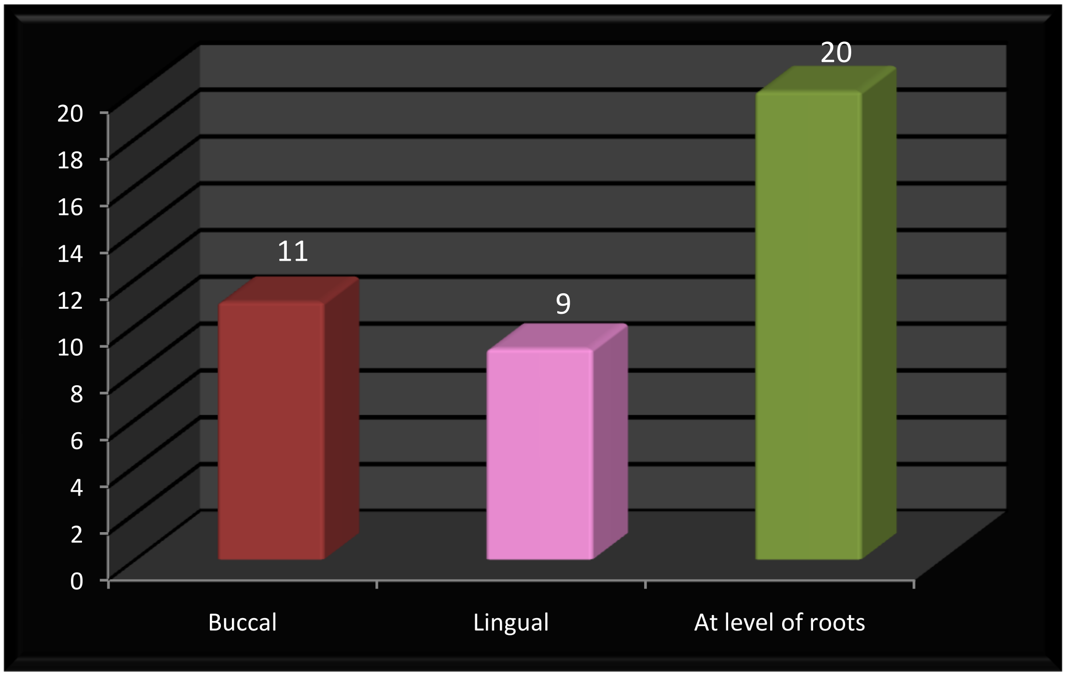


Chart 5: Distribution of supero-inferior position of mandibular canal in CBCT images

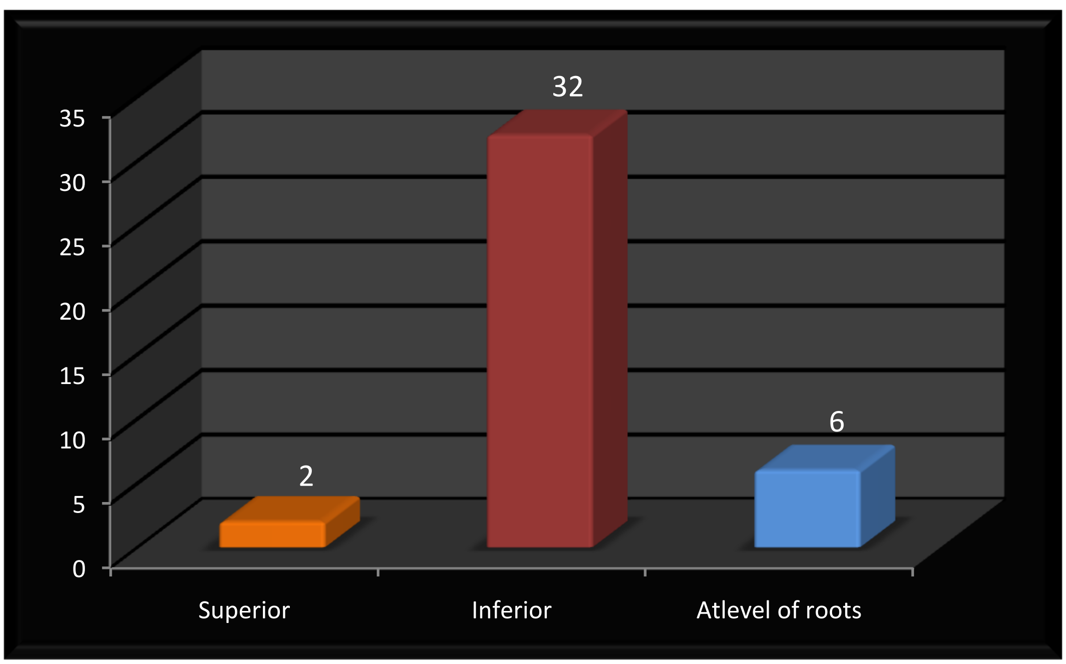
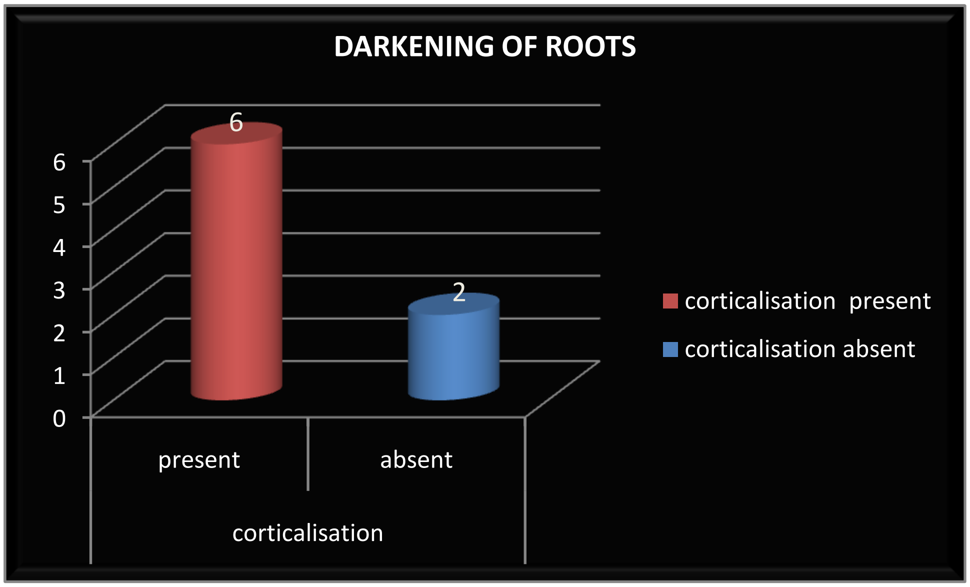


Chart 6 and 7: Correlation of darkening of roots in panoramic radiograph with CBCT findings



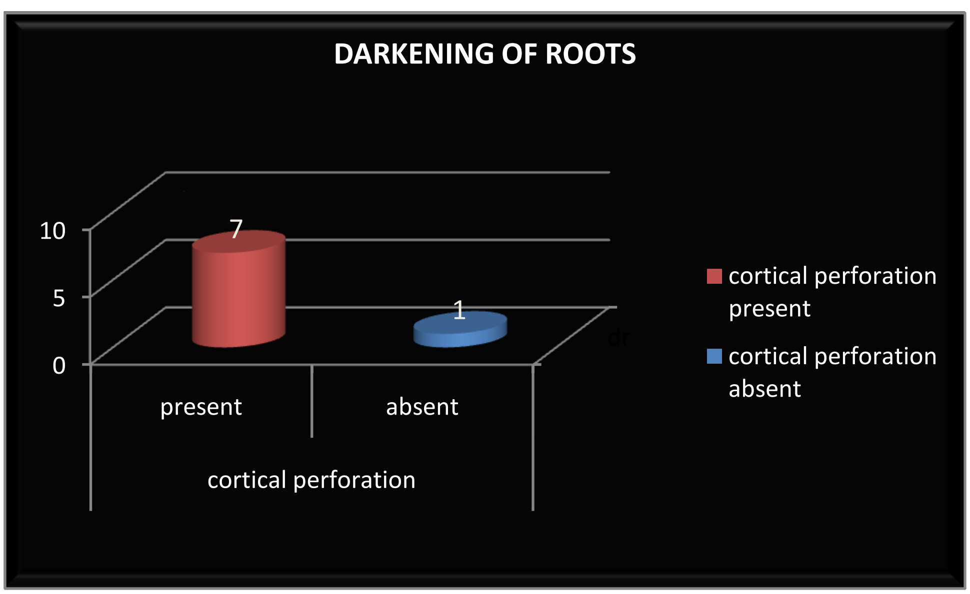
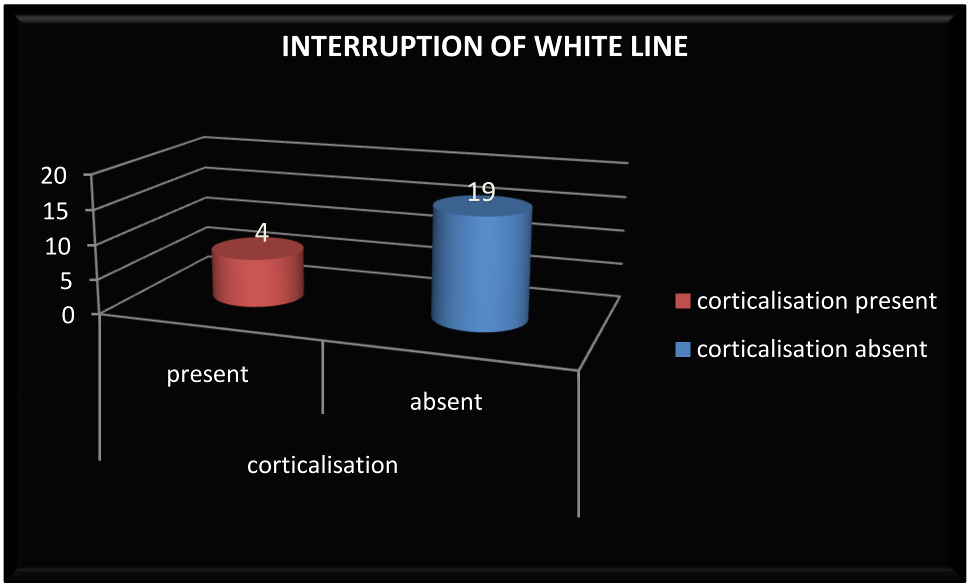


Chart 8 and 9: Correlation of interruption of white line in panoramic radiograph with CBCT findings



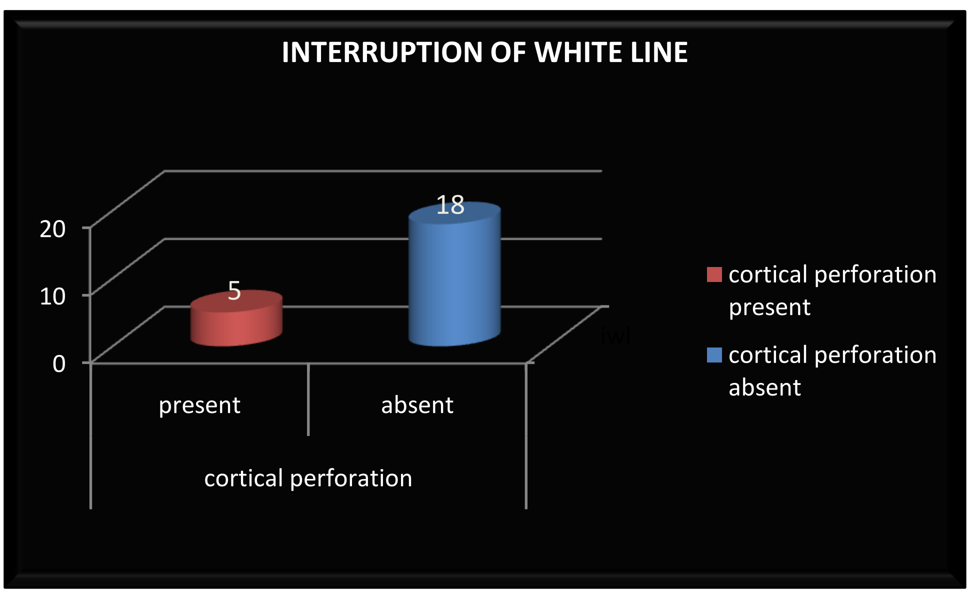
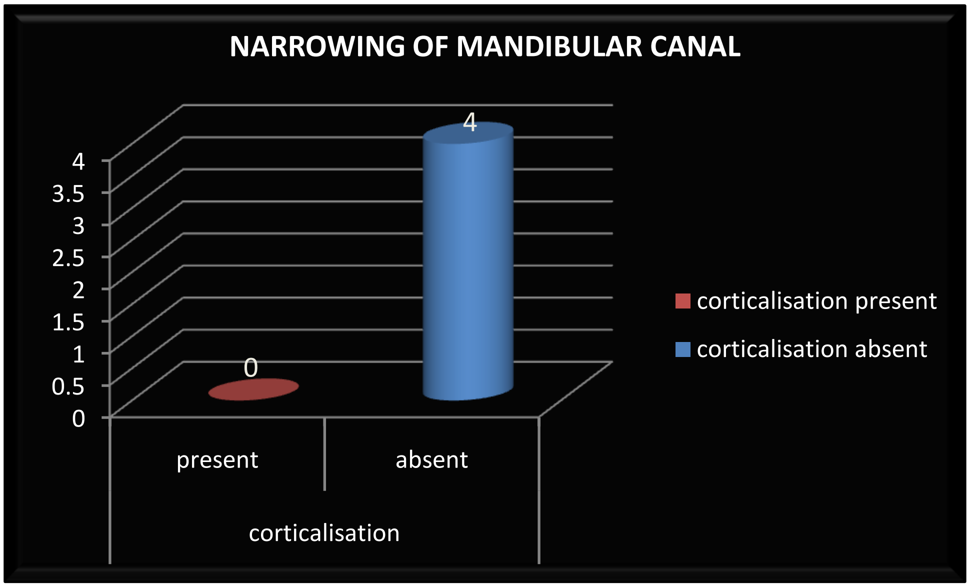


Chart 10 and 11: Correlation of narrowing of mandibular canal in panoramic radiograph with CBCT findings



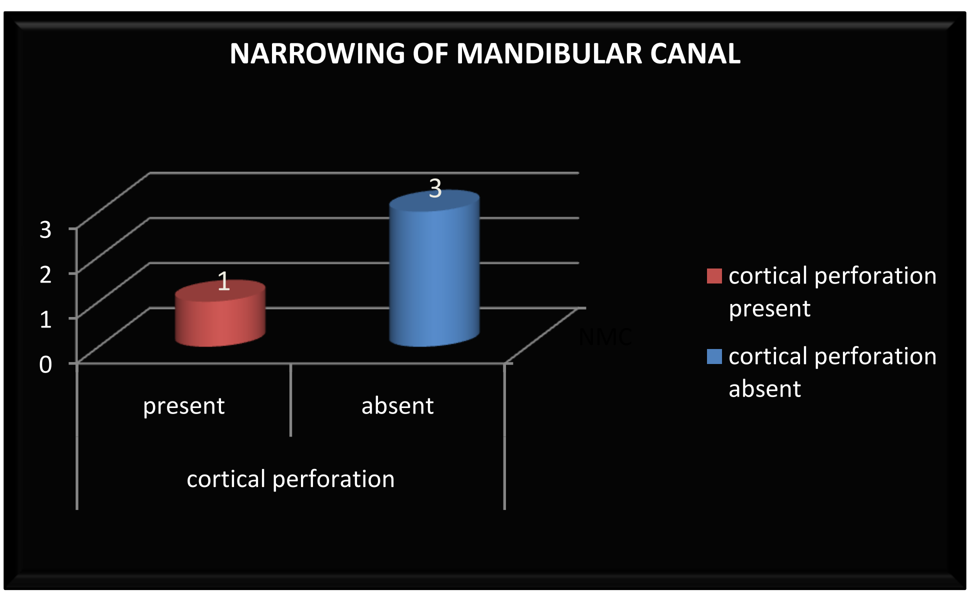
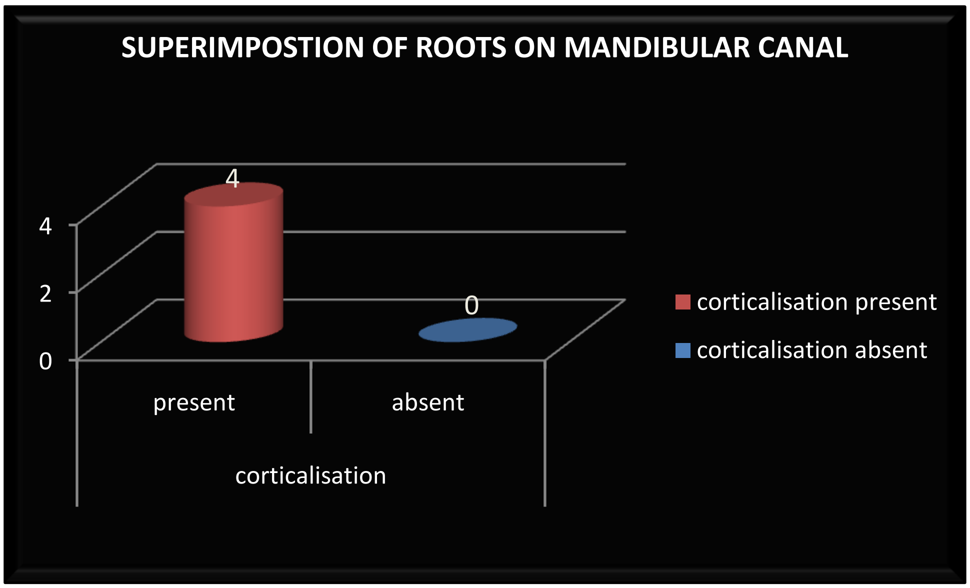


Chart 12 and 13: Correlation of superimposition of roots on mandibular canal in panoramic radiograph with CBCT findings



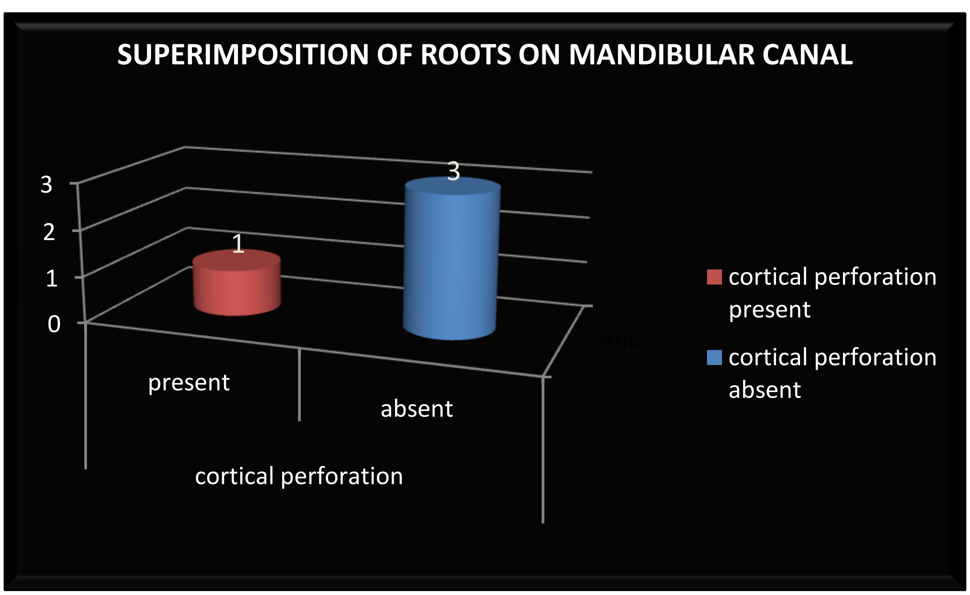
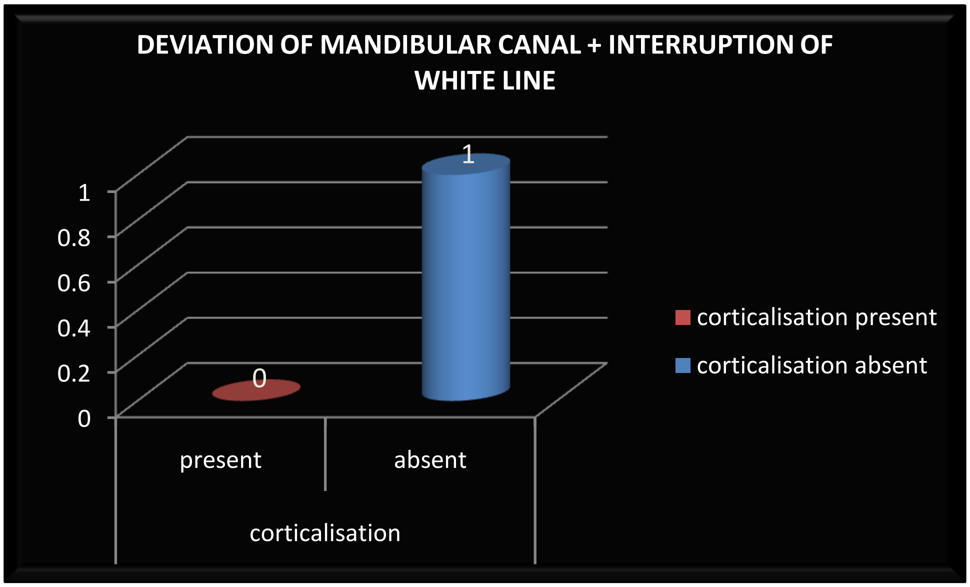


Chart 14 and 15: Correlation of deviation of mandibular canal + interruption of white line in panoramic radiograph with CBCT findings



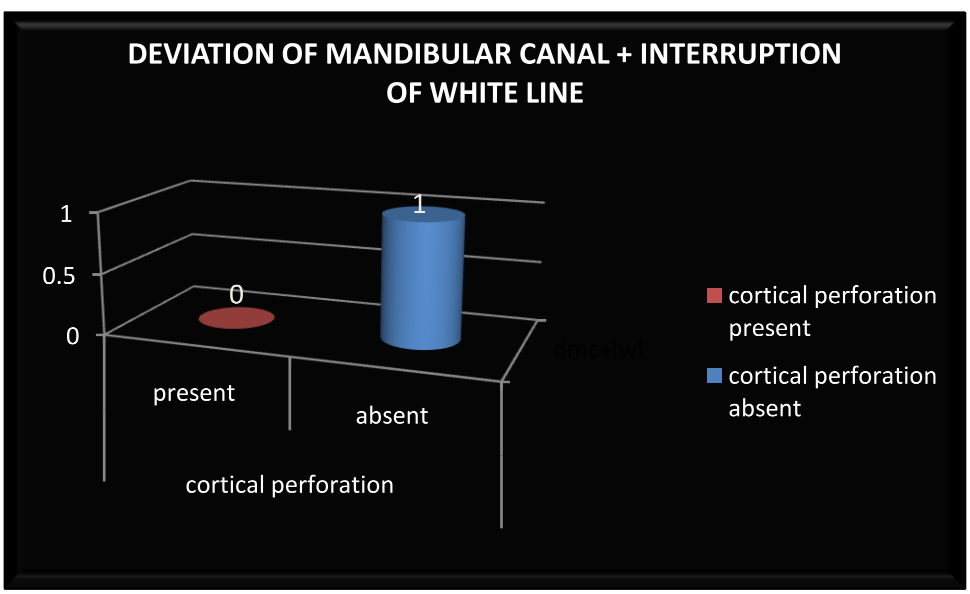


Table 1, 2 and Chart 1 is showing the position of impacted mandibular third molars determined in panoramic radiograph and CBCT reformatted panoramic image based on angulation of tooth. Out of total 40 (100%) cases, 16 (40%) were vertical, 20 (50%) were mesioangular, 2 (5%) were distoangular, and 2 (5%) were horizontal.

Table 3, 4 and Chart 2 is showing the position of impacted mandibular third molars determined in panoramic radiograph and CBCT reformatted panoramic image based on depth of tooth inside bone. Out of total 40 (100%) cases, 12 (30%) were at level A, 9 (22.5%) were at level B, and 19 (47.5%) were at level C.

Table 5 is showing the number of patients showing similar type of impaction on both the sides based on angulation. Out of 20 patients, 6 patients showed vertical impaction both the sides, 7 patients showed mesioangular impaction both the sides, and 1 patient showed distoangular impaction both the side.

Table 6 is showing the number of patients showing similar type of impaction on both the sides based on depth. Out of 20 patients, 4 patients showed level A impaction both the sides, 2 patients showed level B impaction both the sides, and 7 patient showed level C impaction both the sides.

Table 7, 8 and Chart 3 is showing the different findings in panoramic radiograph suggestive of high risk injury sign to inferior alveolar nerve. These findings were also evaluated and confirmed in CBCT reformatted panoramic images. Out of total 40 (100%) cases, 8 (20%) showed DR (darkening of roots), 23 (57.5%) showed IWL (interruption of white line of mandibular canal), 4 (10%) showed NMC (narrowing of mandibular canal), no case (0%) showed DMC (deviation of mandibular canal), 4 (10%) showed SMC (superimposition of roots on mandibular canal), and 1 (2.5%) showed DMC+IWL.

Table 9 and Chart 4 is showing the bucco-lingual position of mandibular canal in relation to roots of impacted mandibular third molars in CBCT. Out of total 40 (100%) cases, in 11 (27.5%) cases canal was buccal, in 9 (22.5%) cases canal was lingual, and in 20 (50%) cases canal was at the level of roots.

Table 10 and Chart 5 is showing the supero-inferior position of mandibular canal in relation to roots of impacted mandibular third molars in CBCT. Out of total 40 (100%) cases, in 2 (5%) cases canal was superior, in 32 (80%) cases canal was inferior, and in 6 (15%) cases canal was at the level of roots.

Table 11 and Chart 6 is showing the association between DR (panoramic finding) and the presence of corticalisation of mandibular canal (CBCT finding) with statistical significance (P value < 0.05).

Table 11 and Chart 8 is showing the association between IWL (panoramic finding) and the absence of corticalisation of mandibular canal (CBCT finding) with statistical significance (P value < 0.05).

Table 11 and Chart 12 is showing the association between SMC (panoramic findings) and presence of corticalisation of mandibular canal (CBCT finding) with statistical significance (P value <0.05).

Table 11 and Chart 10, 14 is showing no association between NMC and DMC +IWL (panoramic finding) and presence or absence of corticalisation of mandibular canal (CBCT finding) with no statistical significance (P value >0.05).

Table 12 and Chart 7 is showing the association between DR (panoramic finding) and presence of cortical plate perforation (CBCT finding) with statistical significance (P value < 0.05).

Table 12 and Chart 9 is showing no association between IWL (panoramic finding) and presence of cortical plate perforation (CBCT finding) with no statistical significance (P value > 0.05).

Table 12 and Chart 11 is showing no association between NMC (panoramic finding) and presence of cortical plate perforation (CBCT finding) with no statistical significance (P value > 0.05).

Table 12 and Chart 13 is showing no association between SMC (panoramic finding) and presence of cortical plate perforation (CBCT finding) with no statistical significance (P value > 0.05).

Table 12 and Chart 15 is showing no association between DMC+IWL (panoramic findings) and cortical plate perforation (CBCT finding) with no statistical significance (P value >0.05).

DISCUSSION

Impaction is the cessation of eruption of a tooth caused by a physical barrier or ectopic positioning of a tooth. Dental impactions have been reported to affect as many as 25-50 per cent of the population with the third molars and maxillary canines bearing the highest incidence.[72]

The term “localization” means “determination of the place or site of any process or lesion” (Dorland).[73] Accurate knowledge of the position of the impacted teeth may contribute to the decision to perform a less invasive procedure when exposure of teeth is required.

Three-dimensional views acquired by cone beam computed tomography (CBCT) have been introduced because of the improbability and limitations of 2-dimensional plain radiography.[72] Also the prognosis of an impaction can be assessed accurately only when the exact position of an impacted tooth and its relationship with the surrounding anatomical structures is well known.

The present study was done to evaluate the various signs in panoramic radiograph which depicts the intimate relationship between mandibular canal and impacted mandibular third molar such as darkening of roots, interruption of white line, narrowing of mandibular canal, deviation of mandibular canal, and superimposition of roots on mandibular canal and correlation of these findings with CBCT findings of presence or absence of corticalisation of mandibular canal, and cortical plate perforation. These high risk injury signs to inferior alveolar nerve in panoramic radiograph were also evaluated in CBCT reformatted panoramic images for comparison and to determine the diagnostic utility of CBCT reformatted panoramic image. Total of 20 patients (11 females and 9 males) were included in the study and total 40 impacted mandibular third molars were assessed in the study.

In our study, 40 impacted mandibular third molars were assessed according to angulation (Winter's classification) into four groups namely mesioangular, distoangular, vertical, and horizontal depending upon the long axis of third molar in relation to the long axis of second molar[74] in both panoramic radiograph as well as CBCT reformatted panoramic images and it was found that most common was mesioangular type (50%), followed by vertical (40%), horizontal (5%), and horizontal (5%) **(Table 1, 2 and Chart 1)**. The study of **Peterson et al (1993)**[75] concluded that the most common mandibular third molar impaction is mesioangular type (43%), then vertical (38%), distoangular (6%), and horizontal (3%). **Sedaghatfar et al (2005)**[65] in their study found maximum number of mandibular third molars to be mesioangular. **Hazza'a et al (2006)**[76] found highest number of vertically placed mandibular third molars followed by mesioangular, distoangular, and horizontal third molars. **Chu et al (2003)**[77] found that maximum number of third molars (80% of 3178 mandibular third molars) was horizontal or mesioangular. The findings of this study were in concordance with Peterson et al and Sedaghatfar et al, these variations in angular position of mandibular third molars may be because of the fact that the studied population in each study was quite different from each other. Pell and Gregory (1942) classified the depth of the impacted third molar compared with the height of the adjacent second molar tooth into Level A impactions (occlusal surface of the impacted tooth level or nearly level with the occlusal plane of the adjacent second molar), Level B impactions (impacted third molar's occlusal surface is between the occlusal plane and the cervical line of the adjacent second molar), and Level C impactions (occlusal surface of the impacted third molar is below the cervical line of the adjacent second molar tooth) [78] according to which 40 impacted mandibular third molars were assessed in panoramic radiograph as well as CBCT reformatted panoramic images. In the present study, most common type found was level C (47.5%), followed by level A (30%), and level B (22.5%) **(Table 3, 4 and Chart 2)**. In this study all the findings of position of mandibular impacted third molars based on angulation as well as depth in panoramic radiograph were consistent with CBCT reformatted panoramic images. A study of **Sandhu and Kaur (2005)**[79] found maximum mandibular third molars at level B followed by level A and level C which was in disagreement with the present study. This variation may be present due to small sample size. In this study, it was also observed that out of 20 patients, 6 patients showed vertical impaction on both the sides, 7 patients showed mesioangular impaction on both the sides, and 1 patient showed distoangular impaction on both the side whereas 4 patients showed level A impaction on both the sides, 2 patients showed level B impaction on both the sides, and 7 patient showed level C impaction on both the sides **(Table 5 and 6)**.

In the present study, we assessed the most common signs such as darkening of roots, interruption of white line of mandibular canal, narrowing of mandibular canal, superimposition of roots on mandibular canal, deviation of mandibular canal, and combination of these findings[13,17,25,26] associated with a higher risk of IAN (Inferior alveolar nerve) injury and suggestive of close relationship between mandibular canal and mandibular third molar in panoramic radiograph and subsequently these findings were also evaluated in the CBCT reformatted panoramic images. In this study most common finding was interruption of white line (57.5%), followed by darkening of roots (20%), narrowing of mandibular canal (10%), superimposition of mandibular canal on roots (10%), and only 1 case was found of deviation of mandibular canal + interruption of white line as a combined feature (2.5%) **(Table 7, 8 and Chart 3)**. Here also, all the findings of high risk radiographic signs of IAN injury in panoramic radiograph were consistent with CBCT reformatted panoramic images. These findings were consistent to the observations of **Monaco et al (2004)**[19] and **Tantanapornkul et al (2007)**[60.] In these studies, panoramic signs of the darkening of the roots and the interruption of the radiopaque border of the canal were the most frequent findings, while panoramic signs of the deviation of the canal and narrowing of the canal were the least frequent, respectively.

In the CBCT images, evaluation of mandibular canal was done using cross sectional images. In present study, position of mandibular canal was localized using CBCT images in vertical plane as superior, inferior, and at the level of roots and also in horizontal plane as buccal, lingual, and at the level of roots. After the evaluation of previously mentioned high risk injury signs to inferior alveolar nerve in relation to impacted mandibular third molars in panoramic radiograph, these findings were correlated with absence or presence of corticalisation of mandibular canal and cortical plate perforation in CBCT images. Various studies have suggested that close proximity of anatomical structures to the tooth bears high risk of injury to inferior alveolar nerve and also in many studies high association was found between absence of corticalisation (absence of cortical lining between tooth root and mandibular canal) and inferior alveolar nerve exposure and injury during impacted mandibular third molar extraction.

In the present study, the position of mandibular canal in horizontal plane was most common at the level of roots (50%), followed by buccal (27.5%), and lingual (22.5%)

(Table 9 and Chart 4) whereas in vertical plane the most common position was inferior (80%), followed by at level of roots (15%), and superior (5%) **(Table 10 and Chart 5)**. These results were not consistent with previous studies. **Monaco et al (2004)**[19] found in their study that highest number of mandibular canal was positioned buccal to the third molar. On the other hand, **Tantanapornkul et al (2007)**[60] found that maximum number of mandibular canal was positioned lingual to the third molar. **Neugebauer J et al (2008)** [54] found that in maximum cases mandibular canal was located buccal in horizontal plane and at the level of roots in vertical plane. These variations may be present due to both sample size as well as variation of study population.

Presence and absence of corticalisation between mandibular third molar and mandibular canal was also evaluated using CBCT cross sectional images. This study revealed that the interruption of white line in panoramic radiograph demonstrated significant association with absence of corticalisation between mandibular canal and mandibular third molar in CBCT with statistically significant value (P value < 0.05) and darkening of roots, superimposition of roots on mandibular canal in panoramic radiograph showed significant association with presence of corticalisation of mandibular canal in CBCT with statistical significance (P value <0.05) **(Table 11)**. Whereas narrowing of mandibular canal and deviation of mandibular canal + interruption of white line in panoramic radiograph showed no association with presence or absence of corticalisation with no statistical significance (P value >0.05) **(Table 11)** hence further studies are needed to be carried out with large sample size taking these parameters to substantiate the results. The results of present study were partially consistent with a study done be **F Sampaio Neves et al (2012)**[71] according to which darkening of roots and interruption of white line associated with the absence of cortical lining between the mandibular third molar and the mandibular canal on CBCT images were statistically significant.

Cortical plate perforation was also assessed in CBCT cross sectional images. This study demonstrated that darkening of roots in panoramic radiograph showed statistical significant association with cortical plate perforation in CBCT with P value < 0.05 but interruption of white line, narrowing of mandibular canal, superimposition of roots on mandibular canal, and deviation of mandibular canal + interruption of white line in panoramic radiograph showed no statistical significant association with cortical plate perforation in CBCT with P value > 0.05 **(Table 12)**. In this study all the cases which showed perforations of cortical plate was of lingual plate. A study done by **W Tantanapornkul et al (2009)**[70] stated that the darkening of the root may represent thinning of the cortical plate. Further studies are necessary to be carried out to study the correlation between interruption of white line, narrowing of mandibular canal, and superimposition of roots on mandibular canal findings in panoramic radiograph and cortical plate perforation in CBCT with larger sample size. Obtaining information about cortical plate perforation is very important and it might serve to lower the risk of injury to lingual nerve, and dislocation of bone or tooth in adjacent structures like floor of mouth or sublingual space.

Radiological examination is essential to evaluate the topographic relationship between mandibular canal and mandibular third molar, and panoramic radiograph is most commonly used tool for this. Moreover panoramic radiograph lacks the ability to provide spatial information in all the three dimensions, and numerous studies have been done to propose some panoramic radiographic signs suggestive of close and intimate relationship between mandibular canal and impacted third molars. Three dimensional views obtained by cone beam computed tomography (CBCT) have been advocated to overcome the limitations of two dimensional radiographs. **Nakayama K et al (2009)**[57] concluded in their study that when assessing the anatomic relation between the IAN and mandibular third molar root apices by means of dental 3D-CT, contact of these two anatomic structures depicts an increased risk for inferior alveolar nerve exposure or injury. **Blaeser BF et al (2003)**[64] and **Sedaghatfar M et al (2005)**[65] said that panoramic findings of diversion of the inferior alveolar canal, darkening of the third molar root, and interruption of the cortical white line are statistically associated with inferior alveolar nerve injury. **Park W et al (2010)**[68] in their study said that loss of mandibular canal cortical integrity is associated with an increased risk of paresthesia following mandibular third molar extraction.

So, panoramic radiograph plays very vital role as the routine screening procedure for preoperative evaluation of mandibular third molars, such as position and the angulation of impacted tooth and its proximity to inferior alveolar nerve. Cases showing classic specific signs indicating close relationship between mandibular third molar and inferior canal such as darkening of roots, interruption of white line, narrowing of mandibular canal, deviation of mandibular canal, diversion of roots, superimposition of roots on mandibular canal in panoramic radiograph needs further topographic evaluation of inferior alveolar canal in relation to tooth in all the planes by means of advanced imaging such as CT, CBCT. In this study, 40 impacted mandibular third molars having above mentioned specific signs prone to nerve injury in panoramic radiograph were assessed and further were subjected to CBCT, in which exact localization of mandibular canal in relation to mandibular third molar was determined, and also these panoramic findings were correlated to absence or presence of corticalisation of mandibular canal in CBCT because the absence of cortical integrity of mandibular canal indicates contact between mandibular canal and tooth, and prone to nerve injury during extraction of tooth, and cortical plate perforation was also evaluated which can lead to complications like lingual nerve injury and displacement of tooth in adjacent spaces during extraction of the tooth. In this study it was found that interruption of white line was associated with absence of corticalisation of mandibular canal and darkening of roots was associated with cortical plate perforation but further studies are needed to confirm these findings as well as taking into consideration the other parameters also which showed non-significant results in present study with large sample size to validate the results. In the present study, the findings such as position of impacted mandibular third molars based on angulation, depth, and various high risk signs of inferior alveolar nerve injury mentioned previously in panoramic radiograph were also evaluated in CBCT reformatted panoramic images and it was found that findings in both, the panoramic radiograph as well as CBCT reformatted panoramic image were consistent, no variations were found. Other potential benefits of CBCT are visualization of structures in all the three planes, nerve canal tool can be used to trace the canal to get precise information, the various image enhancement tools can be used to enhance the images, and also bone density can be measured, all these are achieved at reduced radiation exposure with lesser scanning time and fewer artifacts.

SUMMARY AND CONCLUSION

The present study was done at the department of Oral Medicine and Radiology, Tamil Nadu Government Dental College and Hospital where patient selection was done and Aarthi scan, Vadapalani where panoramic radiograph and CBCT scan were taken. Ethical clearance was obtained from Institutional Ethical Committee. Total 20 patients (40 impacted mandibular third molars) age group ranging from 22 to 30 years (mean age = 26 years) of either gender reported with the symptom of pain in region of mandibular third molars. Informed consent was obtained from all the patients.

The present study was aimed to correlate various panoramic radiographic signs suggestive of high risk injury to inferior alveolar nerve with the CBCT findings of localization of mandibular canal both in horizontal as well as vertical plane, corticalisation of mandibular canal (present or absent), and cortical plate perforation which are high risk factors for the nerve injury. Cases showing high risk injury signs to inferior alveolar nerve like darkening of roots, interruption of white line of mandibular canal, narrowing of mandibular canal, superimposition of roots on mandibular canal, deviation of mandibular canal, and combination of these findings in panoramic radiograph were only included in the study. All the findings in panoramic radiograph like position of tooth inside bone based on angulation, depth, and various high risk signs mentioned previously were also evaluated in CBCT reformatted panoramic image and all the findings were found to be consistent in both the radiographs. CBCT cross sectional images showed that in horizontal plane, mandibular canal was buccal to the mandibular third molar root tip in 11 cases (27.5%), lingual in 9 cases (22.5%), and at the level of roots in 20 cases (50%) whereas in vertical plane, mandibular canal was inferior to the mandibular third molar root tip in 32 cases (80%), at the level of roots in 6 cases (15%), and superior in 2 cases (5%). Interruption of white line showed significant association with absence of corticalisation of mandibular canal (P value <0.05) whereas darkening of roots and superimposition of roots on mandibular canal showed significant association with presence of corticalisation of mandibular canal (P value<0.05). Darkening of roots showed significant association with cortical plate perforation (P value <0.05). Still further studies are required taking these parameters and the other parameters also which showed non-significant results with larger sample size to authenticate and validate the results. In the present study, it was also found that the diagnostic information provided by CBCT reformatted panoramic radiograph was almost equivalent to the panoramic radiograph.

So to conclude, conventional radiography remains basic imaging modality for most of the impacted teeth. Until recent, advanced imaging option was some what limited to the medical conventional fan-beam CT,[16,80,81] but CBCT multiplane 3-D imaging system has been developed specifically for dental use to reduce the exposure.[81,82,83,55] CBCT technique is showing very good results in diagnosis of the spatial relationship between impacted molars and the inferior alveolar nerve.[84,85] The CBCT imaging technology provides the adequate diagnostic information for various indications with lower cost, less device maintenance, and reduced exposure of radiation to the patient.[86,87,88,89] Also commercially available CBCT equipments have been shown to provide diagnostic information almost equal to CT.[20,24]

CBCT determines precise tooth position to visualize impaction with in alveolar bone, inclination of impacted tooth, location relative to adjacent teeth and proximity to vital structures such as nerve canal, and cortical borders.

REFERENCES

1. Maverna R, Gracco A. Different diagnostic tools for the localization of impacted maxillary canines: clinical considerations. Prog Orthod 2007;8:28-44.
2. Kapoor V, Impacted teeth. In Kapoor V(ed) Text book of Oral and Maxillofacial surgery. 2nd edn. pp 53-80. New Delhi:Arya (medi) Publishing House,2005.
3. Jaquiery C, Pajarola GF, Sailer HF, Lambrecht JT. The extraction of retained mandibular wisdom teeth- Indications and preoperative diagnosis. Schweiz Monatsschr Zahnmed 1994;104:1510-19.
4. Joynson OB, Williams SL, Brickley MR, Shepherd JP. Lower third molar treatment planning ability of general dental practitioners and oral maxillofacial surgeons using receiver operating characterstics methodology. Br Dent J 1996;181:411-15.
5. Obiechina AE, Arotiba JT, Fasola AO. Third molar impaction: evaluation of the symptoms and pattern of impaction of mandibular third molar teeth in Nigerians. Odontostomatol Trop 2001;24:22-5.
6. Mercier P, Precious D. Risks and benefits of removal of impacted third molars. A critical review of literature. Int J Oral Maxillofac Surg 1992;21:17-27.
7. Stephens RG, Kogon SL, Reid JA. The unerupted or impacted third molar-a critical appraisal of its pathologic potential. J Can Dent Assoc 1989;55:201-7.
8. Werkmeister R, Fillies T, Joos U, Smolka K. Relationship between lower wisdom tooth position and cyst development, deep abscess formation and mandibular angle fracture. J Craniomaxillofac Surg 2005;33:164-8.

9. Peterson LJ. Rationale for removing impacted teeth: when to extract or not to extract. J Am Dent Assoc 1992;123:198-204.
10. Chandler L, Laskin DM. Accuracy of radiographs in classification of impacted thired molar teeth. J Oral Maxillofac Surg 1988;46:656-60.
11. Valmaseda-Castellon E, Berini-Aytes L, Gay-Escoda C. Inferior alveolar nerve damage after lower third molar surgical extraction:a prospective study of 1117 surgical extractions. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2001;92:377-83.
12. Gulicher D, Gerlach KL. Incidence, risk factors, and follow up of sensation disorders after surgical wisdom tooth removal: Study of 1,106 cases. Mund Kiefer Gesichtschir 2000;4:99-104.
13. Rood JP, Shehab BA. The radiological prediction of inferior alveolar nerve injury during third molar surgery. Br J Oral Maxillofac Surg 1990;28:20-5.
14. Kipp DP, Goldstein BH, Weiss WW Jr. Dysesthesia after mandibular third molar surgery: a retrospective study and analysis of 1,377 surgical procedures. J Am Dent Assoc 1980;100:185-92.
15. Streizel FP, Reichart PA. Wound healing after surgical wisdom tooth extraction. Evidence based analysis. J Mund Kiefer Gesichtschir 2002;6:74-84.
16. Smith AC, Barry SE, Chiong AY, Hadzaki D, Kha SL, Mok SC et al. Inferior alveolar nerve damage following removal of mandibular third molar teeth. A prospective study using panoramic radiography. Aust Dent J 1997;42:149-52.
17. Howe GL, Poyton HG. Prevention of damage to the inferior dental nerve during extraction of mandibular third molars. Br Dent J 1960;109:355-63.

18. Walker L, Enciso R, Mah J. Three-dimensional localization of maxillary canines with cone-beam computed tomography. Am J Orthod Dentofacial Orthop 2005;128:418-2.
19. Monaco G, Montevecchi M, Bonetti GA, Gatto MRA, Checchi L. Reliability of panoramic radiography in evaluating the topographic relationship between the mandibular canal and impacted third molars. J Am Dent Assoc 2004;135:312-18.
20. Hashimoto K, Arai Y, Iwai K, Araki M, Kawashima S, Terakado M. A comparison of new limited cone beam computed tomography machine for dental use with a multidetector row helical CT machine. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2003;95:371-77.
21. Better H, Abramovitz I, Shlomi B, Kahn A, Levy Y, Shaham A. et al. The presurgical workshop before third molar surgery: how much is enough? J Oral Maxillofac Surg 2004;62:689-92.
22. Bouquet A, Coudert JL, Bourgeois D, Mazoyer JF, Bossard D. Contributions of reformatted computed tomography and panoramic radiography in the localization of third molars relative to the maxillary sinus. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2004;98:342-47.
23. Schulze D, Heiland M, Thurmann H, Adam G. Radiation exposure during midfacial imaging using 4- and 16-slice computed tomography, cone beam computed tomography systems and conventional radiography. Dentomaxillofac Radiol 2004;33:83-6.
24. William C. Scarfe, Allan G. Farman, Predag Sukovic. Clinical applications of cone beam computed tomography in dental practice. J Can Dent Assoc 2006;72:75-80

25. Rud J. Third molar surgery: relationship of root to mandibular canal and injuries to the inferior dental nerve. Tandlaegebladet 1983;87:619-31.
26. Swanson AE. Incidence of inferior alveolar nerve injury in mandibular third molar surgery. J Can Dent Assoc 1991;57:327-8.
27. White SC. Assessment of radiation risk from dental radiography. Dentomaxillofac Radiol 1992;21:118-26.
28. Danforth RA, Clark DE. Effective dose from radiation absorbed during a panoramic examination with a new generation machine. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2000;89:236-43.
29. Cohnen M et al. Radiation dose in dental radiology. Eur Radiol 2002;12:634-7.
30. Heiland M, Schulze D, Rother U, Schmelzle R. Postoperative imaging of zygomaticomaxillary complex fractures using digital volume tomography. J Oral Maxillofac Surg 2004;62:1387-91.
31. Frederiksen NL. Health Physics. In White SC, Pharoah MJ(eds) Oral Radiology, Principles and Interpretation.5th ed. pp 47-68. New Delhi, India:Elsevier, 2004.
32. Farman A.G. Tooth Eruption and Dental Impaction. Panoramic imaging news 2004; 2:1-9.
33. Peterson l.J. Principles of Management of Impacted Teeth in: Peterson L.J, Ellis III E, Hupp J.R, Tuker M.R, (Eds). Contemporary Oral & Maxillo- Facial Surgery .3rd ed. St. Louis: Mosby; 1998. Page: 215-48.
34. Archer W.H. Oral Surgery: A Step-By-Step Atlas of Operative Techniques. W.B. Saunders Company, Philadelphia, 1966; 4th ed. Chapter 4: 122-237.

35. Eidelman D. Fatigue on Rest and Associated Symptoms (Headache, Vertigo, Blurred Vision, Nausea, Tension and Irritability) due to Locally Asymptomatic, Unerupted, Impacted Teeth. Medical Hypotheses 1979; 5: 339-346.
36. Mead S V. Oral Surgery 4th ed., pp.507-510, St. Louis: CV Mosby
37. Gravel V, Dermaut L. The effect of tooth position on the image of unerupted canines on panoramic radiographs. Eur J Orthod 1999;23:25-34.
38. Mason C, Papadokou P, Roberts GJ. The radiographic localization of impacted maxillary canines: a comparison of methods. Eur J Orthod 2001;23:25-34.
39. Liu DG, Zhang WL, Zhang ZY, Wu YT, Ma XC. Three-dimensional evaluations of supernumerary teeth using cone-beam computed tomography for 487 cases. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2007;103:403-11.
40. Dudic A, Giannopoulou C, Leuzinger M, Kiliaridis M. Detection of apical root resorption after orthodontic treatment by using panoramic radiography and cone-beam computed tomography of super-high resolution. Am J Orthod Dentofacial Orthop 2009;135:434-7
41. Chaushu S, Chaushu G, Becker A. The role of Digital Volume Tomography in the imaging of impacted teeth. World J Orthod 2004;5:120-132.
42. Halazonetis DJ. From 2-dimensional cephalograms to 3- dimensional computed tomography scans. Am J Orthod Dentofac Orthop 2005; 127: 627–37.
43. Sukovic P, Brooks S, Perez L, Clinthorne NH. DentoCATTM—a novel design of a cone-beam CT scanner for dentomaxillofacial imaging: introduction and preliminary results. CARS 2001; 700–5.

44. Mah J, Hatcher D. Current status and future needs in craniofacial imaging. Orthod Craniofac Res 2003; 6 Suppl 1: 10–6; discussion 179–82.

45. Sukovic P. Cone beam computed tomography in craniofacial imaging. Orthod Craniofac Res 2003; 6 Suppl 1: 31–6; discussion 179–82.

46. Mah JK, Danforth RA, Bumann A, Hatcher D. Radiation absorbed in maxillofacial imaging with a new dental computed tomography device. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2003; 96: 508–13.

47. Robb, R.A., Dynamic Spatial Reconstructor: An X-ray Video Fluoroscopic CT scanner for dynamic volume imaging of moving organs. IEEE Trans Med Im, 1982. MI-1(1): p. 22-23.

48. Fahrig, R., et al., Use of a C-arm system to generate true three- dimensional computed rotational angiograms: preliminary in vitro and in vivo results. American Journal of Neuroradiology, 1997. 18: p. 1507-14.

49. Saint-Felix, D., et al., In vivo evaluation of a new system for 3D computerized angiography. Phys. Med. Biol., 1994. 39: p. 584-95.

50. Jaffray, A.D. and J.H. Siewerdsen, Cone-beam computed tomography with a flat-panel imager: Initial performance characterization. Medical Physics, 2000. 27: p. 1311-1323

51. Leuzinger M, Dudic A, Giannopoulou C, Kiliaridis S. Root-contact evaluation by panoramic radiography and cone-beam computed tomography of super-high resolution. Am J Orthod Dentofacial Orthop. 2010 Mar;137(3):389-92

52. Ozen T, Kamburoglu K, Cebeci ARI, Yuksel SP, Paksoy CS. Interpretation of chemically created periapical lesions using 2 different dental cone-beam

computerized tomography units, an intraoral digital sensor, and conventional film. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2009 Mar;107(3):426-32.

53. Albert DG, Amorim Gomes AC, Vasconcelos BC, Olieveira Silva ED, Holanda GZ. Comparison of Orthopantomography and Conventional Tomography Images for assessing the relationship between Impacted Lower Third Molars and the Mandibular Canal. J Oral Maxillofacial Surg 2006;64:1030-1037.
54. Neugebauer J, Shirani R, Mischkowski RA, Ritter L, Scheer M, Keewe M, et al. Comparison of cone-beam volumetric imaging and combined plain radiographs for localization of the mandibular canal before removal of impacted lower third molars. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2008; 105:633-42.
55. Nakagawa Y, Kobayashi K, Ishii H, Mishima A, Ishii H, Asada K, Ishibashi K. Preoperative application of limited cone beam computerized tomography as an assessment tool before minor oral surgery. Int J Oral Maxillofac Surg. 2002;31:322–327.
56. Ghaeminia H, Meijer GJ, Soehardi A, Borstlap WA, Mulder J, Bergé SJ, Maal TJ. The use of cone beam CT for the removal of wisdom teeth changes the surgical approach compared with panoramic radiography: a pilot study. Int J Maxillofac Surg 2011;40(8):834-9.
57. Nakayama K, Nonoyama M, Takaki Y, Kagawa T, Yuasa K, Izumi K, Ozeki S, Ikebe T. Assessment of the relationship between impacted mandibular third molars and inferior alveolar nerve with dental 3-dimensional computed tomography. Int J Maxillofac Surg 2009;67(12):2587-91.

58. Susarla SM, Dodson TB. Preoperative computed tomography imaging in the management of impacted mandibular third molars. Int J maxillofac surg 2007;65(1):83-8.

59. Flygare L, Ohman A. Preoperative imaging procedures for lower wisdom teeth removal. Clin oral investig 2008;12(4):291-302.

60. Tantanapornkul W et al. A comparative study of cone-beam computed tomography and conventional panoramic radiography in assessing the topographic relationship between the mandibular canal and impacted third molars. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2007;103(2):253-9.

61. Suomalainen A, Venta I, Mattila M, Turtola L, Vehmas T, Peltola JS. Reliability of CBCT and other radiographic methods in preoperative evaluation of lower third molars. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2010;109(2):276-84.

62. Miloro M, DaBell J. Radiographic proximity of the mandibular third molar to the inferior alveolar canal. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2005;100(5):545-9.

63. Szalma J, Lempel E, Jeges S, Szabó G, Olasz L. The prognostic value of panoramic radiography of inferior alveolar nerve damage after mandibular third molar removal: retrospective study of 400 cases. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2010;109(2):294-302.

64. Blaeser BF, August MA, Donoff RB, Kaban LB, Dodson TB. Panoramic radiographic risk factors for inferior alveolar nerve injury after third molar extraction. J Oral Maxillofac Surg 2003;61(4):417-21.

65. Sedaghatfar M, August MA, Dodson TB. Panoramic radiographic findings as predictors of inferior alveolar nerve exposure following third molar extraction. J Oral Maxillofac Surg 2005;63(1):3-7.

66. Susarla SM, Sidhu HK, Avery LL, Dodson TB. Does computed tomographic assessment of inferior alveolar canal cortical integrity predict nerve exposure during third molar surgery? J Oral Maxillofac Surg 2010;68(6):1296-303.

67. Jerjes W et al. Inferior alveolar nerve injury and surgical difficulty prediction in third molar surgery: the role of dental panoramic tomography. J Clin Dent 2006;17(5):122-30.

68. Park W, Choi JW, Kim JY, Kim BC, Kim HJ, Lee SH. Cortical integrity of the inferior alveolar canal as a predictor of paresthesia after third-molar extraction. J Am Dent Assoc 2010;141(3):271-8.

69. Palma-Carrió C, García-Mira B, Larrazabal-Morón C, Peñarrocha-Diago M. Radiographic signs associated with inferior alveolar nerve damage following lower third molar extraction. Med Oral Patol Oral Cir Buccal 2010;15(6):e886-90.

70. W Tantanapornkul, K Okochi, A Bhakdinaronk, N Ohbayashi, T Kurabayashi. Correlation of darkening of impacted mandibular third molar root on digital panoramic images with cone beam computed tomography findings. Dentomaxillofac Radiol 2009;38:11-16.

71. F Sampaio Neves, T de Camargo Souza, S Maria de Almeida, F Haiter-Neto, D Queiroz de Freitas, F Norberto Bo´scolo. Correlation of panoramic radiography and cone beam computed tomography findings in the assessment of the relationship

between impacted mandibular third molars and the mandibular canal. Dentomaxillofac Radiol 2012;000:1-5.

72. Guerrero M, Shahbazian M, Bekkering E, Nackaerts O, Jacobs R, Horner K. The diagnostic efficacy of cone beam CT for impacted teeth and associated features: a systematic review. J Oral Rehabil 2011;38:208-16.
73. Novak PD. In Dorland's illustrated medical dictionary.27thed. pp 496. Philadelphia:Saunders,2004.
74. Winter, GB. Impacted mandibular third molar. St Louis, American Medical Book Co., 1926.
75. Peterson LJ, Ellis E, Hupp J, and Tucker M. Contemporary Oral and Maxillofacial Surgery, 2nd ed., C.V. Mosby Co., St. Louis, 1993;237-242.
76. A. M. Hazza'a, Z. S. M. Albashaireh, and A. B. Bataineh. The relationship of the inferior dental canal to the roots of impacted mandibular third molars in Jordanian population. J Contem Dent Prac 2006;7(2):1-9.
77. F. C. S. Chu, T. K. L. Li, V. K. B. Lui, P. R. H. Newsome, R. L. K. Chow, and L. K. Cheung. Prevalence of impacted teeth and associated pathologies—a radiographic study of the Hong Kong Chinese population. Hong Kong Medical Journal, 2003;9(3):158-63.
78. Pell GJ, Gregory G. Report on a ten year study of a tooth division technique for the removal of impacted teeth. Am J Orthod 1942;28:660-669.
79. S. Sandhu and T. Kaur. Radiographic evaluation of the status of third molars in the Asian-Indian students. J Oral Maxillofac Surg 2005;63(5):640-45.

80. Francis PO, Fowler EB, Willard CC. Migrating third molar: a report of a case. Mil Med 2003;168:802-6.
81. Aria Y, Tammisalo E, Iwai K, Hashimoto K, Shinoda K. Development of a compact computed tomographic apparatus for dental use. Dentomaxillofac Radiol 1999;28:245-8.
82. Baba R, Ueda K, Okabe M. Using a flat-panel detector in high resolution cone beam CT for dental imaging. Dentomaxillofac Radiol 2004;33:285-90.
83. Mozzo P, Procacci C, Tacconi A, Martini PT, Andreis IA. A new volumetric CT machine for dental imaging based on the cone-beam technique: preliminary results. Eur Radiol 1998;8:1558-1564.
84. Danforth RA, Peck J, Hall P. Cone beam volume tomography: an imaging option for diagnosis of complex mandibular third molar anatomical relationships. J Calif Dent Assoc 2003;31:847-52.
85. Heurich T, Ziegler C, Steveling H, Wortche R, Muhling J, Hassfeld S. Digital volume tomography-an extension to the diagnostic procedures available for application before surgical removal of third molars. Mund Kiefer Gesichtschir 2002;6:427-32. German.
86. Guerrero ME, Jacobs R, Loubele M, Schutyser F, Suetens P, Van Steenberghe D. State-of-the-art on cone beam CT imaging for preoperative planning of implant placement. Clin Oral Investig 2006;10:1-7.
87. Danforth RA. Cone beam volume tomography: a new digital imaging option for dentistry. J Calif Dent Assoc 2003;31:814-5.

88. Ludlow JB, Davies-Ludlow LE, Brooks SL, Howertan WB. Dosimetry of 3 CBCT devices for oral and maxillofacial radiology: CB Mercuray, NewTom 3G and i-CAT. Dentomaxillofac Radiol 2006;35:219-26.
89. Ludlow JB, Davies-Ludlow, Brooks SL. Dosimetry of two extraoral direct digital imaging devices: NewTom con beam CT and Orthophos Plus DS panoramic unit. Dentomaxillofac Radiol 2003;32:229-34.

APPENDIX

DEPARTMENT OF ORAL MEDICINE AND RADIOLOGY,

TAMIL NADU GOVERNMENT DENTAL COLLEGE AND HOSPITAL,

CHENNAI- 600 003

"CONE BEAM COMPUTED TOMOGRAPHY VERSUS PANORAMIC RADIOGRAPH-ASSESSMENT OF RELATIOSHIP BETWEEN IMPACTED THIRD MOLARS AND MANDIBULAR CANAL"

PROFORMA

Patient's name :

Age/sex :

Contact address :

Contact number :

Occupation :

Income :

Institution : Tamil Nadu Government Dental College and Hospital,
Chennai- 600 003.

Centre : Aarthi Scans,
60, 100 feet road, Vadapalani,
Chennai- 600 026, and

Dept. of Oral Medicine and Radiology,
Tamil Nadu Govt. Dental College and Hospital,
Chennai- 600 003.

Patient's Dental OPD No. : Date :

Chief complaint :

Medical history :

Clinical examination :

Radiographic investigation :

- Panoramic radiograph :

- CBCT imaging :

Inferences :

Signature of PG student Signature of Guide

Date:

INFORMED CONSENT FORM

STUDY TITLE:

CONE BEAM COMPUTED TOMOGRAPHY VERSUS PANORAMIC RADIOGRAPH- ASSESSMENT OF RELATIONSHIP BETWEEN IMPACTED THIRD MOLARS AND MANDIBULAR CANAL

Name: O.P.No:

Address: Serial No:

Age / Sex:

Tel. no:

I, ____age____years

Exercising my free power of choice, hereby give my consent to be included as a participant in the study "Cone beam computed tomography versus panoramic radiograph-Assessment of relationship between impacted third molars and mandibular canal". I agree to the following:

- I have been informed to my satisfaction about the purpose of the study and study procedures including investigations to monitor and safeguard my body function.
- I agree to give my full participation for the study.
- I agree to cooperate fully and to inform my doctor immediately if I suffer any unusual symptom.
- I agree to report to the doctor for a regular follow-up as and when required for the research.
- I hereby give permission to use my medical records for research purpose. I am told that the investigating doctor and institution will keep my identity confidential.

Name of the patient Signature / Thumb impression

Name of the investigator Signature Date

INFORMATION SHEET

- We are conducting a study on "Cone beam computed tomography versus Panoramic radiograph- Assessment of relationship between impacted third molars and mandibular canal". For that study, we are selecting patients.

- The purpose of this study is to evaluate and compare the diagnostic utility of conventional radiograph using panoramic radiograph with that of cone beam computed tomography for assessing relative position of the root tip of impacted mandibular third molar and the mandibular nerve for clinical assessment.

- The identity of the patients participating in the research will be kept confidential throughout the study. In the event of any publication or presentation resulting from the research, no personally identifiable information will be shared.

- Taking part in the study is voluntary. You are free to decide whether to participate in the study or to withdraw at any time; your decision will not result in any loss of benefits to which you are otherwise entitled.

- The results of the special study may be intimated to you at the end of the study period or during the study if anything is found abnormal which may aid in the management or treatment.

Name of the patient Signature / Thumb impression

Name of the investigator Signature Date

DECLARATION

TITLE OF DISSERTATION	**"Panoramic radiograph and Cone beam computed tomography- Evaluation of Mandibular impacted third molar and Mandibular canal"**
PLACE OF STUDY	**1)Tamil Nadu Government Dental College and Hospital, Chennai-600003** **2)Aarthi scan, 60, 100 feet road, Vadapalani, Chennai-600 026**
DURATION OF THE COURSE	**3 Years**
NAME OF THE GUIDE	**DR.S.Jayachandran M.D.S, Ph.D**
HEAD OF THE DEPARTMENT	**DR.S.Jayachandran M.D.S, Ph.D**

I hereby declare that no part of the dissertation will be utilized for gaining financial assistance/any promotion without obtaining prior permission of the Principal, Tamil Nadu Government Dental College and Hospital, Chennai-600003. In addition, I declare that no part of this work will be published either in print or in electronic media without the guide who has been actively involved in dissertation. The author has the right to reserve for publish of work solely with the prior permission of the Principal and Guide, Tamil Nadu Government Dental College & Hospital, Chennai-600003.

Guide and Head of the Department **Signature of the candidate**

TRIPARTITE AGREEMENT

This agreement herein after the "Agreement" is entered into on this day...................... between the Tamil Nadu Government Dental College and Hospital represented by its **Principal** having address at Tamil Nadu Government Dental College and Hospital, Chennai - 600 003, (hereafter referred to as, 'the college')

And

Mr. Dr. S. Jayachandran,MDS.,Ph.D aged 49 years working as **Professor & HOD** in Department of Oral Medicine and Radiology at the college, having residence address at A.M 16, TNHB Quarters, Todhunter Nagar, Saidapet, Chennai – 600 015 (herein after referred to as the 'Principal Investigator')

And

Dr. Khushboo Singh aged 27 years currently studying as **Post Graduate student** in Department of Oral Medicine and Radiology, Tamilnadu Government Dental College and Hospital, Chennai - 3 (herein after referred to as the 'PG student and co-investigator').

Whereas the PG student as part of his curriculum undertakes to research on "**PANORAMIC RADIOGRAPH AND CONE BEAM COMPUTED TOMOGRAPHY- EVALUATION OF MANDIBULAR IMPACTED THIRD MOLAR AND MANDIBULAR CANAL"** for which purpose the Principal Investigator shall act as principal investigator and the college shall provide the requisite infrastructure based on availability and also provide facility to the PG student as to the extent possible as a Co-investigator.

Whereas the parties, by this agreement have mutually agreed to the various issues including in particular the copyright and confidentiality issues that arise in this regard.

Now this agreement witnesseth as follows

1. The parties agree that all the Research material and ownership therein shall become the vested right of the college, including in particular all the copyright in the literature including the study, research and all other related papers.
2. To the extent that the college has legal right to do go, shall grant to licence or assign the copyright so vested with it for medical and/or commercial usage of interested persons/entities subject to a reasonable terms/conditions including royalty as deemed by the college.
3. The royalty so received by the college shall be shared equally by all the three parties.

4. The PG student and Principal Investigator shall under no circumstances deal with the copyright, Confidential information and know – how - generated during the course of research/study in any manner whatsoever, while shall sole west with the college.
5. The PG student and Principal Investigator undertake not to divulge (or) cause to be divulged any of the confidential information or, know-how to anyone in any manner whatsoever and for any purpose without the express written consent of the college.
6. All expenses pertaining to the research shall be decided upon by the Principal Investigator/Co-investigator or borne sole by the PG student.(co-investigator)
7. The college shall provide all infrastructure and access facilities within and in other institutes to the extent possible. This includes patient interactions, introductory letters, recommendation letters and such other acts required in this regard.
8. The Principal Investigator shall suitably guide the Student Research right from selection of the Research Topic and Area till its completion. However the selection and conduct of research, topic and area of research by the student researcher under guidance from the Principal Investigator shall be subject to the prior approval, recommendations and comments of the Ethical Committee of the College constituted for this purpose.
9. It is agreed that as regards other aspects not covered under this agreement, but which pertain to the research undertaken by the PG student, under guidance from the Principal Investigator, the decision of the college shall be binding and final.
10. If any dispute arises as to the matters related or connected to this agreement herein, it shall be referred to arbitration in accordance with the provisions of the Arbitration and Conciliation Act, 1996.

In witness whereof the parties hereinabove mentioned have on this the day month and year herein above mentioned set their hands to this agreement in the presence of the following two witnesses.

College represented by its **Principal** **PG Student**

Witnesses **Student Guide**

1.

2.